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ABSTRACT

Traditional and evolving attitudes toward energy and the compelling reasons for studying energy use and conservation are highlighted in this guide for elementary-secondary school teachers in the instruction of basic energy attitudes. Sample lessons/activities/objectives are presented from three approaches: attitude development, decision making, and action. Charts, graphs, and illustrations are provided as background material for teachers, and the loose-leaf format of the document allows for easy reproduction. An extensive bibliography of journal articles is included. (MJB)

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ED152773

A TEACHER'S HANDBOOK ON ENERGY

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Prepared under the direction of

The Governor's Energy Advisory Council

in consultation with

The Texas Education Agency

January 1977

SP012 579

OFFICE OF THE GOVERNOR
STATE CAPITOL
AUSTIN, TEXAS 78711

DOLPH BRISCOE
GOVERNOR

Dear Educator:

This publication is prepared to assist educators in their concern for the preservation and conservation of our natural resources. Our state is experiencing the ending of a period of excess fossil fuel energy availability. For the near term energy supplies will be expensive and in some cases scarce. In order to minimize the effects of this transition period there must be created an increased awareness of issues and alternatives related to our present energy situation.

No segment of our society is in a better position to respond immediately and comprehensively than the educational community. I feel confident that you will find these materials of great value as you share in this urgent undertaking.

Sincerely,

DOLPH BRISCOE
Governor of Texas

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I. EVALUATION

How Do I Use This Handbook?

At first glance the size of this volume may appear intimidating. But if teachers will examine its format, we think teachers will be able to easily find ways to use it to best suit their needs.

In the Introduction we have identified traditional attitudes toward energy. Be sure to examine carefully the section entitled "Why StudyEnergy?"

The checklists and activities are designed to provide teachers with a wide variety of easy to use tools to make their students aware of energy.

Sections C,D, E, and F provide background material for teachers. The many charts, graphs and illustrations are designed to provide teachers with many graphic ways they can help their students understand this difficult topic. The loose leaf format will enable the teacher to remove specific pages and reproduce them.

The Bibliography and Resource Material Section (H) provides teachers with additional sources they may use to investigate this complex topic.

Give us a grade in the Evaluation section. Tell us your likes and dislikes. How might we improve the handbook?

Foreword

There are several reasons why energy topics are appropriate for introduction into the Texas Public School Systems curricula. Perhaps the most compelling are the following.

The nation no longer has a surplus of energy supplies. The serious shortages in gas and oil availability during the last few years are less dramatic symptoms of the problems Americans will face in the near future. An informed and enlightened public has been cited as the nation's primary defense against the problems created by shortages in our energy supplies. The Texas economy is heavily dependent on energy availability.

Whether individuals squander energy resources through ignorance or inefficiency, the results are the same - costly. Educational programs which increase the public's knowledge of energy conservation methods will be of benefit to the American public for two major reasons: (1) Increased efficiency of energy use through conservation techniques can lower the general public's energy costs. (2) Conservation of energy supplies will enable future generations of Americans to enjoy the energy benefits our society enjoys today.

This Teacher's Handbook on Energy is designed to provide information to Texas teachers to help students better understand current and projected energy problems.

The document is not a comprehensive school curriculum resource guide on energy and energy resource problems, but is rather an attempt to pull together information and instructional activity suggestions of help to teachers.

The Handbook was compiled from a wide variety of resource material made available to the Governor's Energy Advisory Council as well as material researched by the Council's staff. The activities section is, in large part, from energy conservation curriculum guides developed and distributed by the State Departments of Education in Washington, Oregon and Colorado.

Special permission has been granted to the Governor's Energy Advisory Council to use and reprint selected materials from a booklet entitled "A Teacher's Handbook on Energy" published by the Colorado Department of Education.

ENERGY TERMINOLOGY

Throughout the sections of this Teacher's Handbook the terms British Thermal Unit (BTU), Calorie, and barrel will appear in reference to an energy measurement. For a better understanding of energy concepts the teacher and student should understand and be able to convert these measurements.

Barrel (bbl)

A liquid measure of oil, usually crude oil, equals to 42 American gallons or about 306 or 0.159 cubic meters. For crude oil 1 bbl is about 0.136 metric tons, 0.134 long tons, and 0.150 short tons. The energy values of petroleum products per barrel are: crude petroleum 5.6 million Btu/bbl; residual fuel oil - 6.29; distillate fuel oil - 5.83; gasoline - 5.25; jet fuel (kerosine type) - 5.67; jet fuel (naptha type) - 5.36; kerosine - 5.67; petroleum coke - 6.02; and asphalt - 6.64.

British Thermal Unit (BTU)

The quantity of heat necessary to raise the temperature of one pound of water one degree Fahrenheit. One Btu equals 252 calories, gram (mean), 778 foot-pounds, 1055 joules and 0.293 watt-hours.

Brown Coal and Lignite

Brownish-black coals that contain about one-half water. Lignite is the harder type of brown coal. There are large deposits of lignite in the northwestern United States and in western Canada.

Calorie

A unit of heat energy equal to the amount of heat that will raise the temperature of one gram of water 1 degree centigrade. (cal.) The calorie is used when temperature is measured on the Centigrade scale, while the British thermal unit is used when the measurement is on the Fahrenheit scale. One calorie equals 3.97 x 103 Btu, 4.18 joules, and 1.10 x 103 watt-hours. For energy issues, the usual term is the kilocalorie, or 1000 calories.

Coal Gasification

The conversion of coal to a gas suitable for use as a fuel. Cf. Hygas, CO_2-acceptor, Bi-gas, methanation, Lurgi ATGAS processes.

Fission

The splitting of a heavy nucleus into two approximately equal parts (which are radioactive nuclei of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously, but usually is caused by nuclear absorption of neutrons or other particles.

Fusion (or Thermonuclear Power)

The formation of a heavier nucleus from two lighter ones, such as hydrogen isotopes, with the attendant release of energy. The reaction produces hydrogen bomb explosions and is the energy source of the sun and other stars. It has been described as the "No. 1 Holy Grail" and the "Last Dutchman Mine" of atomic science. Most scientists agree that it will eventually provide an ultimate source of clean, cheap, and inexhaustible energy, but estimates of the time needed for its development vary from 10 to 100 years.

Advantages are: no radioactive wastes are produced as a result of the full cycles. They also produce less thermal pollution than fission reactors.

In-Situ Recovery

Refers to methods to extract the fuel component of a deposit without removing the deposit from its bed.

Natural Gas

A natural hydrocarbon gas composed of a variety of gases including methane, ethane, butane, and propane. It comes from the ground with or without accompanying crude oil and is generally much higher in heat content than manufactured gas. It is used as the raw material in the petrochemical industry for the manufacture of fertilizer and celophane. The energy content of natural gas is usually taken as 1,032 Btu/Cu.Ft.

Natural Gasoline

A mixture of liquid hydrocarbons extracted from natural gas and stabilized to obtain a liquid product suitable for blending with refinery gasoline. This gasoline cut is used as a blending stock since it is volatile and aids in engine starting. Natural gasoline has good anti-knock qualities.

Quad

Quadrillion Btu - 10^{15} (thousand million million) Btu's; equal to the heat value of 965 billion cubic feet of gas, 175 million barrels of oil, or 38 million tons of coal.

mcf = 1,000 cubic feet of natural gas

mwe = Megawatts electrical = 10^6 watts electrical

Therm = A unit of heat equal to 100,000 Btu's.

ENERGY CONVERSION FACTORS

1 kilogram calorie = 1,000 gram-calories = 1 Calorie

1 kilogram calorie = 4 BTU's

SOURCE

Coal:

	Unit		BTU's	Calories
Anthracite	1 ton	=	25,400,000	6,350,000
Bituminous	1 ton	=	26,200,000	6,550,000
Lignite	1 ton	=	15,000,000	3,750,000
Briquettes	1 ton	=	28,000,000	7,000,000
Coke	1 ton	=	24,800,000	6,200,000
Natural Gas:				
	1 cu. ft.		1,031	257.75
	1 mcf		1,031,000	257,750
	1 therm.		100,000	25,000
Natural Gas Liquids (Avg.)	1 bbl.		4,011,000	1,002,750
Butane	1 bbl.		4,284,000	1,071,000
Propane	1 bbl.		3,843,000	960,750
Petroleum:				
Asphalt	1 bbl.		6,640,000	1,660,000
Coke	1 bbl.		6,024,000	1,506,000
Crude Oil	1 bbl.		5,800,000	1,450,000
Diesel	1 bbl.		5,806,000	1,451,500
# 2 Fuel Oil	1 bbl.		5,880,000	1,470,000

Petroleum (Cont.):

	Unit	BTU's	Calories
Gasoline (Motor Fuel)	1 bbl.	5,250,000	1,312,500
Gasoline (Motor Fuel)	1 gal.	125,000	31,250
Gasoline (Aviation)	1 bbl.	5,048,000	1,262,000
Jet Fuel (Commercial)	1 bbl.	5,670,000	1,417,500
Kerosene	1 bbl.	5,670,000	1,417,500
Lubricants	1 bbl.	6,060,000	1,515,000
Electricity:	1 kwh	3,143	785.75
Uranium:			
U_3O_8 (Yellow Cake)	1 lb.	60,000,000 - 150,000,000	15,000,000 - 37,500,000

INTRODUCTION

For years the concern for proper natural resource use was confined to a very small group of serious-minded conservationists. A majority of the American people felt that America's energy resources were unlimited. There was little apparent need for the average citizen to be concerned about the wise use of energy resources.

Although many people warned of the critical need to practice conservation, and to consider the potential limit of our resources, they were often thought of as people who wanted to go back to a cave existence. In addition, these individuals were often considered prophets of doom in their predictions. Consequently, the throw-away society flourished almost unchallenged.

In the early 70's, the conservation ethic took a new form. The need to avoid the waste of resources, and to consider environmental degradation was supported by a larger, more vocal group of citizens.

Now the energy problem is on the minds of practically every citizen. However, there are still those who refuse to believe that the crisis is real and continue to find excuses for justifying continued waste.

Hopefully, we will finally begin to take to heart what the conservationists have been telling us for years: The world is finite, our resources are finite, and if we wish to maintain a comfortable life style in a technological society, we must adopt the conservation ethic. The quality of our future existence depends on it.

WHY STUDY ENERGY?

Aside from being able to grasp the meaning of the term energy crisis, which is heard almost daily, the rationale for developing this interdisciplinary Handbook is to provide teachers and students with an understanding of the role and importance played by energy in our daily lives. Because most forms of energy are not visible, it is easy to take them for granted.

Limited Energy Resources. The world's supply of natural resources, especially those which go into the production of energy, is finite. The geological forces which create these natural resources operate so slowly that they can be considered non-renewable. Until recently little thought or attention has been given to what will happen when these much needed raw materials become scarce or ultimately depleted.

Increased Energy Use. Despite the recognized limits of the resource base, the world's appetite for energy continues to grow. The rapidly expanding use of the earth's natural wealth is particularly significant in North America where the current "standard of living" is heavily based on energy abundance.

Environmental Problems. The increased production of goods and services resulting in the increased use of natural resources has caused environmental problems. For instance, manufacturing can create air and water pollution. The utilization of energy-powered equipment, such as automobiles, results in sixty percent of the air pollution problems. Further, when worn out goods and equipment are disposed of, there are litter and solid waste problems which also demand the use of energy resources.

Political Problems. To compound the problems already noted, the less affluent people of the world aspire to the same economic and social levels currently enjoyed by most western countries. However, experts tell us that there are not enough natural resources to support everyone in the world at this level of affluence. Many so-called underdeveloped countries are the source of materials rapidly being used by the industrial nations. It is not surprising, therefore, that the prices charged by the underdeveloped countries for their natural resources and raw materials are increasing steadily.

Mineral Resources. It has been said that the world has ample mineral wealth and that we need only new technologies to exploit this wealth. One point that is neglected in this argument is that it requires energy to transform raw materials into products and to create more energy. As traditional sources of energy become scarce, and the industrial nations are forced to rely on "lower grade" energy sources, more and more of our limited energy supplies will be funneled into the production of energy. The use of "lower grade" energy sources in the production of energy will result in less net energy produced for every unit of energy used in the production process.

New Sources of Energy. If we are to continue to use even larger quantities of natural resources, a way must be found to provide the energy to process the raw materials and to eliminate adverse environmental effects. Scientists working on perfecting the nuclear breeder reactor think it will be one answer. The same thought is expressed by those who forecast ways to utilize the sun's energy, geothermal energy, wind power, fusion, solid waste energy conversions, magnetohydrodymics, and others. Currently, however no one can point, with any assurance, to any single source as the prescription that will cure our energy ills.

Supply and Demand. Energy demands are now exceeding the available supply of conventional high grade energy resources.

Although we knew these resources to be finite and rising energy demands were projected a number of years ago, no long-range plans were formulated to slow the rising rate of energy consumption or to develop alternative energy resources to those being used.

Assuming we cannot or will not reduce energy consumption, we are forced to exploit energy resources that have large environmental trade-offs for short-term energy gains.

Long-range planning for multiple alternative long-lived energy sources is needed if we are to maintain both the quality of the environment and life itself.

EXPRESS LANE
BUSSES
and
CARPOOLS
ONLY

ACTIVITIES

INTRODUCTION TO ACTIVITIES

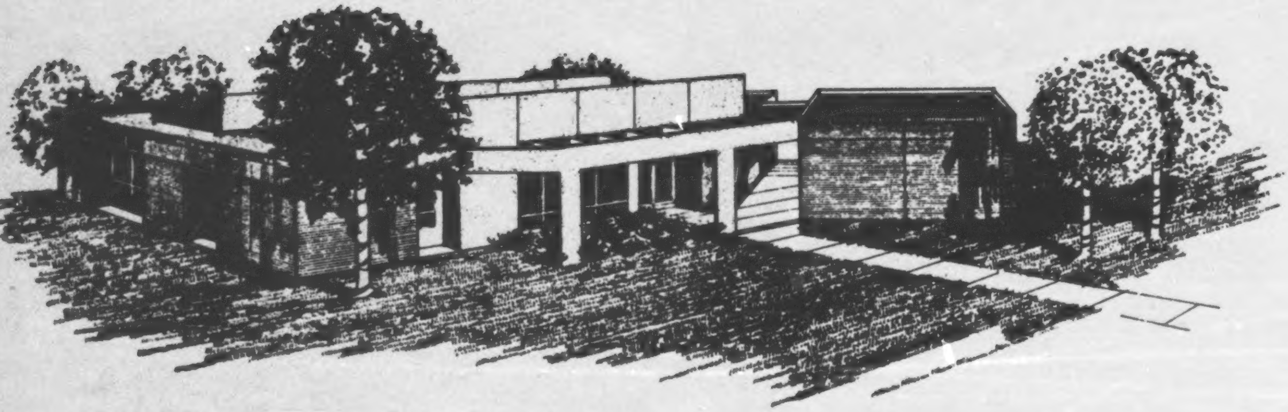
GENERAL STATEMENT OF INTENT - PURPOSE

The accompanying sample lessons/activities/objectives are presented with the purpose of actively involving all students and teachers within the State of Texas. Sample lessons are presented with these objectives: (1) to help the teacher place the student in the role of a decision maker, and (2) to place the student in the role of active learner rather than the passive recipient of facts or knowledge. It is further anticipated that students will carry out these tasks at home, school and throughout the community. It is hoped that many of the attitudes which will be developed will have a lasting effect on the community and will contribute to voluntary cut-backs of all energy uses. It is further hoped that students will communicate with parents and other community members to help maintain a constant awareness of energy conservation measures.

The included sample lessons/activities/objectives are in no way exhaustive. Through student-teacher involvement, many additional activities can be developed in the solution of our national problem of conserving the world's energy sources.

We have included three broad overlapping types of activities in this handbook. They are in the areas of attitude development; decision making; and action approaches.

In light of present and future energy needs, it is important to examine our attitudes. Up to this point we have been operating from an attitudinal framework which encourages consumption. This framework is not compatible with the concept of efficient resource utilization.



It is important that attitudes be developed which reflect an awareness of individuals of their responsibilities to all mankind. An awareness that the actions of any one person or group have both a direct and indirect effect on the quality of life for all people.

Activities should be provided in a school setting to develop these attitudes. Students should have a wide range of energy related activities in which a direct cause and effect relationship between personal actions and energy consumption is demonstrated.

Attitudes rest with individuals. For attitudes to modify personal behavior individuals must take part in the decision-making processes. If the educational activities are solely teacher-imposed, teacher-directed, and teacher-evaluated, attitudinal changes will probably not develop. To be of lasting effect, the student must be involved through various learning activities. Learning is an action activity. We learn by doing. The greater the number of activities the greater the opportunity for decision-making. The more decisions made by the student the more likely attitudes will develop.

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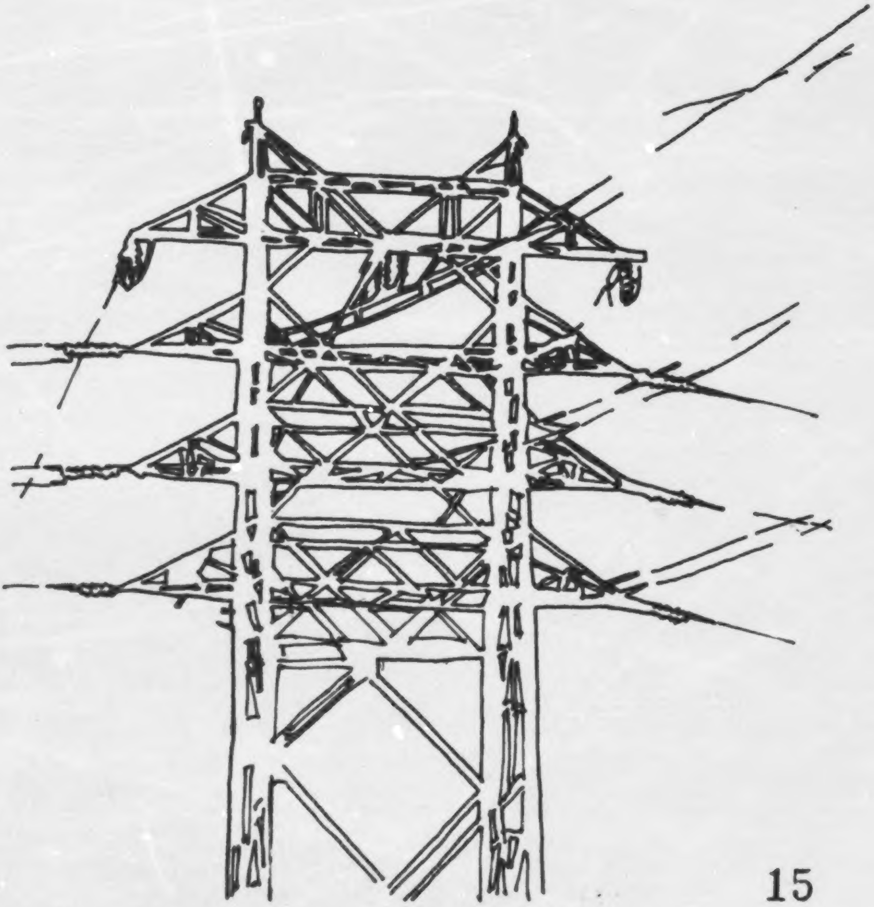

OBJECTIVES FOR ACTIVITIES

Student Objectives:

The student should be able to:

- Carry out selected tasks that will curtail the wasteful use of energy.
- Illustrate with data that we have been wasting our energy resources.
- Demonstrate an energy saving attitude by performing conservation actions.
- Develop statements which point out the interrelatedness of energy use and conservation.
- State measures he can take to ensure energy savings.

Teacher Objectives:

The teacher will utilize selected charts, pictures, data, and/or concepts within the handbook. This may be observed in classroom usage after distribution of the handbook.

The teacher will add to and/or alter the handbook to continually meet the relative needs for energy education. This may be measured by the fact that individual teachers will add to the handbook ideas and activities that are self-generated, student-generated, coordinator-generated or committee-generated.

The teacher will search his/her existing curriculum to determine places where energy activities could be included to enhance the total educational experience. This may be measured by instances when any particular teacher incorporates energy education into existing curriculum.

ACTIVITIES

With the aid of a tape recorder, interview people in the community to ascertain their reactions to the energy situation. Some questions might be:

(1) What do you believe should be done to solve America's energy shortages?
(2) What types of energy conservation activities can you perform to save energy where you live?

*Add to this list by encouraging student participation.

Using this tape, develop a statement which reflects the attitudes of your community toward the energy situation. Develop a plan of action to encourage/change the existing attitudes.

* * * * * * * * * * * * * * * *

Using newspapers, magazines or any other publications, collect a series of cartoons or drawings showing past, present and/or future attitudes of people in our country concerning the energy situation.

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Energy is used in bringing water to you, and in returning it to the river. Make a chain drawing showing where energy is used.

* * * * * * * * * * * * * * * *

Find out how much water your household uses in a day or month. You can figure out what the major uses of water are in your house by taking a few simple measurements. For example, a toilet uses about 7 gallons of water every time you flush it. Can you figure out how much water is used in:

bath or shower?
watering the garden?
personal use (drinking and cooking)?

How can water use be cut down in your house?

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Sketch, photograph or in some way visually describe power. Discuss and compare different kinds of power. Which of these is most powerful? Least powerful? Why?

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Go through your school/home/community and find evidence for efficient use of energy and inefficient use of energy. Through a class discussion formulate plans for making the inefficient uses more efficient.

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Create an "Energy Awareness" award and give them to individuals, schools, or businesses that save energy.

* * * * * * * * * * * * * * * *

Go outside and count the number of faculty cars. Obtain the number of faculty in the school. On a map of the city, locate where the teachers live who are driving cars. Identify the shortest routes to and from school and any possible combinations of people who could ride together in one car.

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Through a series of weekly (monthly) observations, record the actions of people as they relate to energy conservation. Following the observation, conduct a personal interview of the people observed to obtain a record of what they say, they do, and they believe. Compare the two pieces of data. Prepare a statement which shows the comparison between what people say and the actions they perform.

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Go outside and find an energy change that is predictable. Identify the energy source that is changing and what it is changing to. Using drawings, pictures or sketches, show new uses for this changed energy.

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Interview ten people with full size cars and ten people with small cars. Ask each group general energy questions. Compare each group's answers. Are the attitudes different? If the attitudes are different, why?

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Photograph examples of energy located within your community. Trace each of the examples to its original source. Become familiar with the process which transfers raw energy into a useful task.

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Using tempera paints, paint a mural on school and/or community buildings showing some form of energy conservation.

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Create a one minute radio or T.V. commercial dealing with some aspect of energy conservation. Use any medium for a class presentation. (Consider how many people your commercial has to reach to change school/community attitudes and whom your commercial has to convince.)

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Prepare a "What I Personally Believe/Do Not Believe" chart. List all those things you have heard, read, or have been told regarding the energy situation under the appropriate heading. Once listed, research each statement to gather data supporting your "belief." Record any changes of your "beliefs."

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When people get angry or upset, or even when they feel really good, they usually have something or someone that "makes them feel that way." Make a list of the things that occur in regards to the energy situation that makes you feel an emotion.

* * * * * * * * * * * * * * * *

Record the annual amount of electrical energy used in terms of dollar figures for each of the following electrical items:

toothbrush
hot water heater
lights
radio
standard range
rotisserie
toaster
freezer
air conditioner
television
radar range (microwave)
dishwasher

Using this information, categorize the five electrical items which use the most electrical energy and those which use the least electrical energy.

* * * * * * * * * * * * * * * *

How do you use electrical energy in your day-to-day life? For one day, keep track of the times you use electricity. Also, list the purpose for which you used the electricity.

USE	PURPOSE
1. Electric can opener	1. Open dog food can
2.	2.

Could you eliminate any of these in order to conserve energy?

* * * * * * * * * * * * * * * *

Speak with people that work on different jobs (farmer, miner, government worker, teacher, plumber, etc.). Ask each worker how he might conserve energy in his work.

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Compare/contrast the amount of energy used and the benefits received from the following pairs of alternatives:

1. dishwasher vs doing dishes in sink
2. electric razor vs blade razor
3. power mower vs hand mower
4. gas stove vs electric stove
5. shower vs bath

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Locate things both inside and outside of your school that represent power. If they were eliminated, what effect would this have on your world?

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With someone who chooses to cooperate, try to reach as many conclusions as you can about his/her opinions, biases, etc., regarding the energy situation.

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Using the chart below, list those items commonly used in the home/school which are now considered luxury items, convenience items, and necessary items:

LUXURY	CONVENIENCE	NECESSITY

Items in the "necessity" column that were once considered either "luxury" or "convenience" items? Are there any "luxury" or "convenience" items that may become a "necessity" in the future?

Define: luxury convenience necessity

How does an item become a luxury; a convenience; or a necessity?

ELECTRIC USERS

(Figure your electric use - where can you save energy?)

Energy User	Power (Watts)	Time used per day (hours)	Energy consumed per day (Watts X hours)
Air cleaner	50		
Air Conditioner (room)	1,566		
Bed Covering	177		
Blender	386		
Broiler	1,436		
Carving Knife	92		
Clock	2		
Clothes Dryer	4,856		
Coffee Maker	894		
eep Fryer	1,448		
Dehumidifier	257		
Dishwasher	1,201		
Egg Cooker	516		
Fan (attic)	370		
Fan (circulating)	88		
Fan (window)	200		
Floor Polisher	305		
Freezer (15 cu. ft.)	341		
Freezer frostless (15 cu. ft.)	440		
Frying Pan	1,196		
Germicidal Lamp	20		
Hair Dryer	381		
eater (portable)	1,322		
Heater (Infrared)	250		

Energy User	Power (Watts)	Time used per day (hours)	Energy consumed per day (Watts X hours)
Heating pad	65		
Hot plate	1,257		
Humidifier	177		
Iron (hand)	1,008		
Mixer	127		
Oven, Microwave	1,500		
Oven, Self-cleaning	4,800		
Radio	71		
Radio/record player	109		
Range	12,200		
Range, Self-cleaning	12,200		
Refrigerator/Freezer (14 cu. ft.)	326		
Refrigerator/Freezer (Frostless, 14 cu. ft.)	615		
Roaster	1,333		
Sandwich grill	1,161		
Sewing machine	75		
Shaver	14		
Sun Lamp	279		
Television (black & white) tube type	160		
Television (black & white) solid state	55		
Television (color) tube type	300		
Television (color) partial solid state	200		
Toaster	1,146		

Energy User	Power (Watts)	Time used per day (hours)	Energy consumed per day (Watts X hours)
Toothbrush	7		
Trash compactor	400		
Vacuum Cleaner	630		
Vibrator	40		
Waffle Iron	1,116		
Washing Machine (automatic)	512		
Washing Machine (manual)	286		
Waste Disposal	445		
Water heater (standard)	2,475		
Water heater (quick-recovery)	4,474		

CHECKLIST FOR SAVING ENERGY

The following lists of energy conservation ideas have been taken from recently published sources pertaining to the current energy shortage.

Indicate which group(s) could assume responsibility for accomplishing these tasks.

(1) Children
(2) School
(3) All People

HEATING AND COOLING

	Children	School	All People
Insulate all heating, piping and ducts exposed.			
In winter, set thermostats at 68 degrees during the daytime, 65 degrees at night.			
Eliminate use of air conditioning until room temperature is above 78 degrees.			
Avoid blocking heating vents with draperies or furniture.			
Close the damper on your fireplace chimney when not in use.			
Keep doors to corridor closed, (except when thermostat is in corridor)			
Turn off and/or close all heat/air conditioning vents in unoccupied rooms.			
Do not heat hallways or storage rooms.			
In winter, keep draperies open during the daytime to utilize solar heat.			
Put draperies, shades, or blinds at all windows.			
Keep heating and cooling vents free from obstructions.			

Children	School	All People	
			In winter, use an extra blanket at night instead of additional heat.
			Wear more clothing in cold weather.
			UTILITIES
			Use cold or warm water, rather than hot water, whenever possible.
			Wash only full loads in dishwasher and washing machine.
			Use less water for showers and baths.
			Don't leave water running while brushing teeth.
			Keep a jar of water in the refrigerator so that you don't have to run tap water waiting for it to get cool.
			Hang clothes outside to dry whenever possible.
			Reduce bulb wattage where practical.
			Keep television, radios, and stereos, off when not in use.
			Keep lights off when room is not in use.
			Turn off lights whenever natural lighting is suitable.
			Eliminate yard lights. Turn on porch lights only when expecting visitors.

	Children	School	All People
MAINTENANCE			
Replace broken windows.			
See that doors and windows fit frames properly.			
Install weather-stripping around all windows and doors.			
Repair leaking fixtures.			
Clean lighting fixtures, lamps, reflectors, and shades.			
Walls and ceilings should be washed periodically and repainted as necessary.			
Regularly replace air conditioner and heater filters.			
TRANSPORTATION			
Reduce speed.			
Maintain a steady highway speed in harmony with traffic conditions and posted speed limits.			
Reduce idling.			
Drive in a car pool.			
Use public transportation.			
Ride your bike.			

Children	School	All People

JUST SCHOOL

Schedule all school meetings during daylight hours.

Schedule extracurricular activities and community activities for daylight times.

Rearrange seating to keep people as far from exterior walls and windows as possible.

Maintain halls, gyms, and auditoriums at a lower temperature (65 degrees). (In winter)

During vacations and weekends, reduce thermostats to 55 degrees. (In winter)

Reduce lighting in gyms, locker rooms, shower rooms, shops, libraries and general work areas by turning on one row of lights at a time until desired level of lighting is reached.

OTHER EFFORTS

Write your Congressman; make your feelings known on bills affecting the energy problem.

Invite a qualified speaker to address your class on energy concerns.

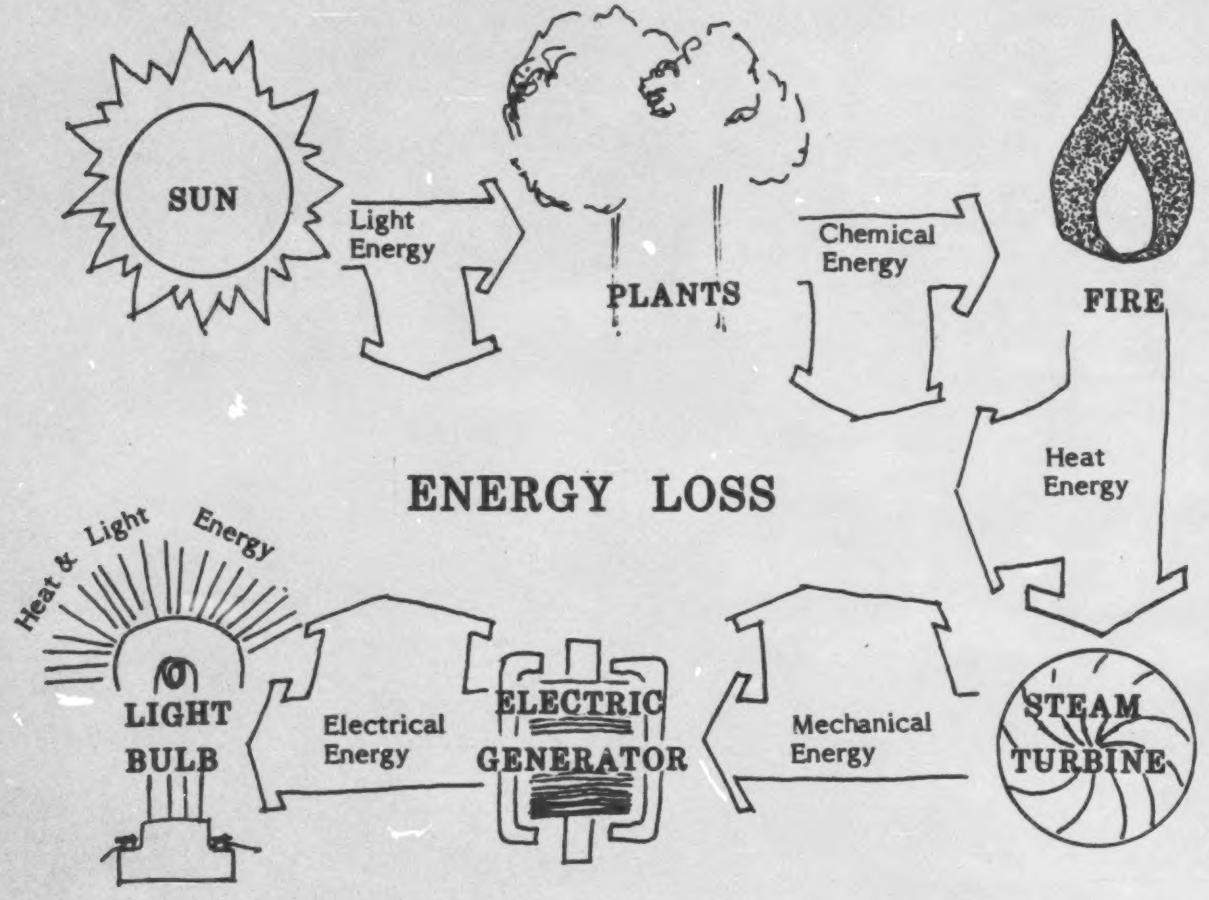
Make local news media aware of your interest in adequate coverage of energy related news.

U.S. ENERGY
Where does it come from? How much do we have?

Energy equals the capacity to do work and power is the rate at which work is done. Energy powers the biosphere and allows us to maintain our agricultural and industrial civilization. Radiant energy flowing from the sun warms the earth to temperatures which sustain life, drives the hydrological cycle of evaporation and precipitation, powers the winds and ocean currents, and is captured by the green plant which is the food base for most living things. The plant is also the starting point of fossil fuels.

Two ideas about energy are important in understanding energy problems:

1. Energy is not really consumed but only changed in form. For example, energy could flow through the system diagramed below:


SUN
Light Energy
PLANTS
Chemical Energy
FIRE
Heat Energy
STEAM TURBINE
Mechanical Energy
ELECTRIC GENERATOR
Electrical Energy
LIGHT BULB
Heat & Light Energy
ENERGY LOSS

2. When energy is converted from one form to another as shown above NOT ALL the energy is changed to the new form . . . SOME IS ALWAYS LOST OR WASTED.

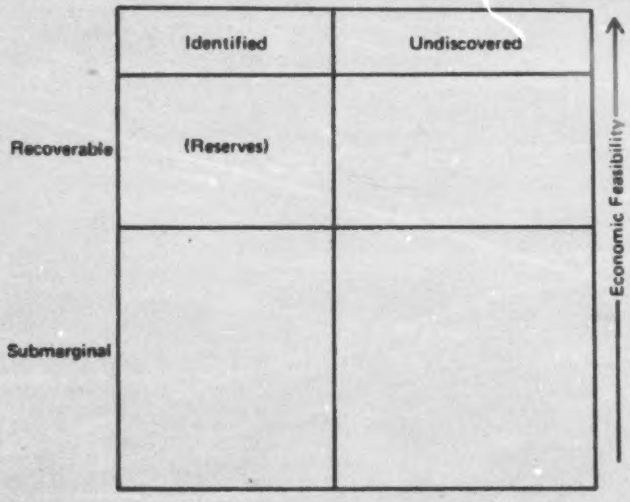
The more conversions between the primary source of energy and the final use of the energy the greater the energy loss.

THE FOSSIL FUELS

The stockpiles of the fossil fuels are difficult to measure. They are in fact part of the small planet we live on and must be discovered and extracted before we really know how much is there. Our numbers will, therefore, have built-in uncertainty.

In order to give some idea of the degree of uncertainty, we will present our data in the categories indicated by Figure 1. Resource estimates may fall into one of two categories either "identified" or "undiscovered." In turn each of these categories may be subdivided into portions which are "recoverable" or "submarginal." Either a resource has been found — "identified" or it is believed to exist — "undiscovered." In the distinction between recoverable and submarginal resources, both price and technological "knowhow" should be taken into account. In the case of coal, for instance, it is not presently economical to recover coal from thin seams. In the case of oil shale, all of this resource was considered submarginal until the increase in oil prices in 1973-1974 made it appear that this resource might become economically recoverable in the future. We will present, in the text and illustrations which follow, the estimates of resources in these various categories relying on data from the U.S. Geological Survey.[1]

FIGURE 1



Presentation of Resource Data (Area of rectangles are proportional to resource amount)

Recovery: It is, unfortunately, not enough to present estimates for the total amounts of resources. What we are really interested in is how much of the resource we can mine or pump for our use. We need, therefore, to know more about the actual extraction processes and the economics which determine the use of such processes. In the traditional method of underground coal mining, for instance, the mine roofs are supported by pillars of coal and about 50 percent of the coal is left in the mine for this purpose. In surface mining 75-95 percent of the coal is recovered depending on terrain and other factors.

Oil has a lower recovery rate. With present techniques, only 31 percent of the oil is extracted; two barrels are left in the ground for every one recovered. Techniques are under development to improve this recovery percentage. In one, underground oil is set on fire with the hope that the fire, advancing across the pool, will heat the remaining oil, increase the pools pressure, and drive more oil to the surface. In others, steam and water under pressure are used to force more oil to the surface or detergents are added to make thick oil flow more easily.

Natural gas, being highly mobile, is more easily recoverable than oil. We are able to extract up to 80 percent of the total discovered amount of this fuel. But in "tight" formations where rock porosity is low, little natural gas can be extracted by conventional technology.

These recovery percentages are used in the resource summaries which follow to compute the "recoverable" amount of a fuel (50 percent in the case of coal, for instance), while the nonrecoverable amount is included in the "submarginal" categories. Let us now briefly consider each of the fossil fuels.

Coal: Coal is the most plentiful of our fossil fuels. We call it fossil because it is made up of the remains of once-living plants. It dates from the Paleozoic era, 300-500 million years ago. The earth at that time was warm and wet and the atmosphere had a higher carbon dioxide content than it does now. In this "greenhouse" environment vegetation flourished. The carbon we burn as coal today was taken from the air's carbon dioxide by the strange jungles of giant mosses and ferns which covered much of the earth in that era.

These plants died, fell into the mud and water of those swampy jungles, were preserved from decay (which would have released their energy) by the water covering them, and gradually built up, layer after layer, into a thick deposit. These layers were covered by tons of earth washed down from the mountains. Under that pressure and the resulting high temperatures, the volatile gases (hydrogen and oxygen and their compounds) and the water were driven off. Coal is as much as 80 percent carbon in contrast to the 50 percent or so in living material. Since the energy resides largely with the carbon (and is released by combination with oxygen in burning), coal has a higher energy density than living material. Burning a pound of wood, for instance, releases only about 1,250 Calories of energy, while one pound of high grade coal releases 3,100 Calories when burned.

Knowing how coal was formed helps greatly in finding it. It is possible from outcroppings, drillings, etc. to estimate fairly accurately how much is in a given seam. The U.S. Geological Survey estimates of this resource are given in Figure 2. Figure 3 shows where it is and how it can be mined.

Coal "reserves" that have been identified and are economically recoverable, amount to 390 billion (B) tons. For comparison, 640 million (M) tons of coal were mined in 1975. In addition to these reserves, another 1,200 B tons of coal that are not at present economically feasible to extract have been identified. This "submarginal-identified" resource includes (a) the other 50 percent of the coal left in the ground, (b) the coal found in thin seams. The Geological Survey warns us that the reserves are known to an accuracy of only about 20-50 percent while the undiscovered submarginal resources might be in error by as much as a factor of five or 10.

FIGURE 2

U.S. Coal Resources (in billions of tons)

	Identified resources	Undiscovered resources	
		0-3,000 ft overburden	(c)
Recoverable	200[a]		0
	190[b]		
Submarginal	1,200	1,300	340

Source: "Energy Resources of the U.S.," P. K. Theobald, S. P. Schweinfurth, and D. C. Duncan, Geological Survey Circular 650, Washington, D.C. 1972.

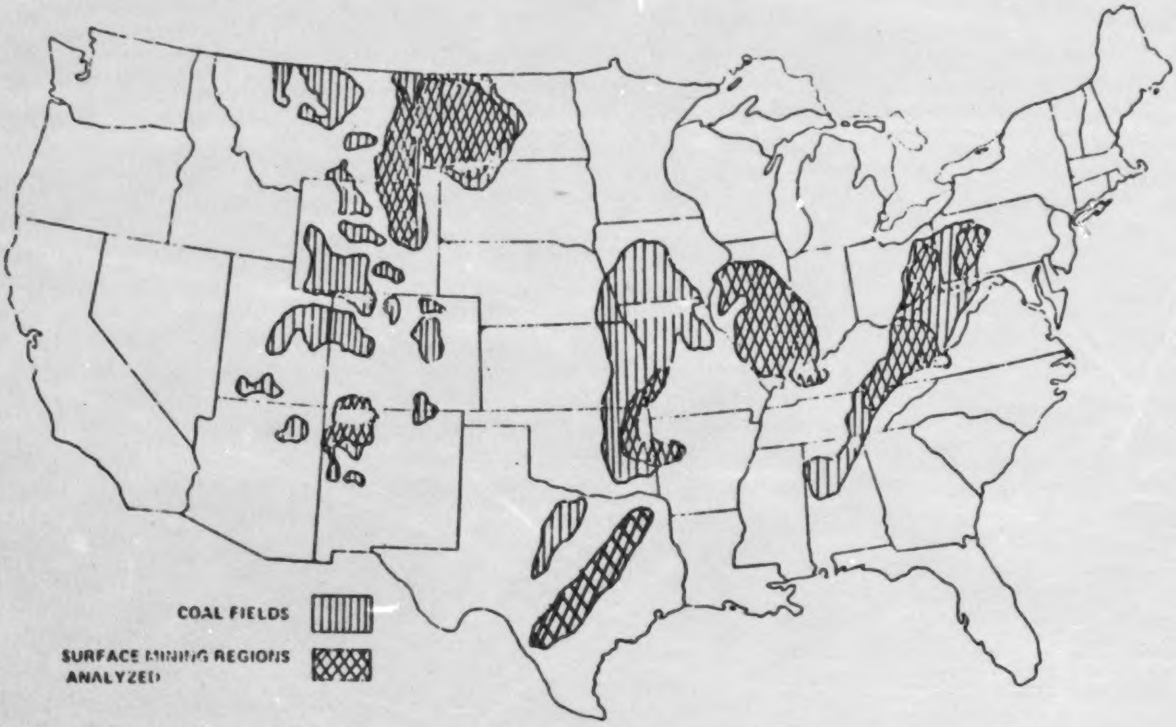
(a) Recoverable coal in beds 42 inches or more in thickness for bituminous coal and anthracite and 10 feet or more in thickness for subbituminous coal and lignite.

(b) Additional coal recoverable in beds 20-42 inches in thickness for bituminous coal and anthracite and 3-5 feet in thickness for subbituminous coal and lignite.

(c) 3000-6000 ft overburden

FIGURE 3

Coal Fields in the United States



Source: U.S. Energy Outlook, National Petroleum Council, December 1972.

The "reserves," the coal that has been identified and is economically recoverable, amount to 390 billion (B) tons. For comparison, 640 million (M) tons of coal were mined in 1975. In addition to these reserves, another 1,200 B tons of coal that is not at present economically feasible to extract has been identified. This "submarginal-identified" resource includes (a) the other 50 percent of the coal left in the ground, (b) the coal found in thin seams. The Geological Survey warns us that the reserves are known to an accuracy of only about 20-50 percent while the undiscovered submarginal resources might be in error by as much as a factor of five or 10.

We summarize the resource picture in terms of Calories as well as B tons in Table 1. The question of what totals to display returns to trouble us. The "reserves" seriously underestimate the potential fuel; oil, for instance, is being discovered every day and added to the reserve category. The sum of all the four blocks of figures like 2 are misleading in the other direction, much of the submarginal category will never be mined or pumped or perhaps even discovered. The choice we have made is shown in Table 1. We show the "reserves" which are the lower limit of the fuel available and then the total of the "recoverable" category, which is effectively an upper limit consistent with present technology and economics. The third category, "total resources," does not provide a realistic estimate of potential; we include it to show that even this category, while large, is still finite.

TABLE 1

U.S. Coal Resources

Category	Amount (B tons[a])		(Q Calories[a])	
Reserves[b]		390		2,380
Thick Seams[c]	200		1,220	
Intermediate Seams[d]	190		1,160	
Ultimately Recoverable	no additional discovery			
Total Resource		3,200		19,500

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

[a] B (billion, 10^9) tons; Q (quadrillion, 10^{15}) Calories.

[b] A recovery of 50 percent is assumed.

[c] Greater than 42" for high grade coal and 10' for lower grade coal.

[d] 28" to 42" for high grade and 5' to 10' for low grade coal.

The coal resources, in contrast to oil resources as we shall see, are pretty well known. The 390 B tons of reserves are, however, already large compared to other fuels and the improvement of mining technology to bring its recovery factor above 50 percent will shift some of the 1,200 B tons of submarginal resources into the reserve category.

Oil: Oil is formed by a process similar to the one that produces coal. Instead of being the fossil remains of plant life, however, oil seems to have been formed from sea animals as well as plant remains which sank to the bottom of the great seas that covered the earth in earlier geologic periods. Oil is younger than coal. Oil was also formed by pressure and the resulting heat, but instead of the simple carbon atoms which form the crystalline solid of coal, petroleum consists of a great variety of complicated hydrocarbon molecules. The petroleum products themselves range from the thick heavy tars and asphalts (the largest molecules), through the oils, gasoline, and kerosene, to the natural gases like methane, which is a carbon atom plus four hydrogen atoms. The various lighter components of petroleum are formed from the heavier ones by "cracking", they are broken down by the heat. It is this same process which is used in a refinery to produce gasoline (one of the lighter molecules) and the other products, kerosene, diesel oil, the fuel oils, etc.

We can again from the rough knowledge of its formation guess where oil will be found. The areas to explore are the sedimentary basins which were once oceans. Oil, however, is not as predictable as coal, and the same kind of rock which will be loaded with oil in Iran will be dry in Australia. Even in the well-explored United States it is estimated that more than half the oil is yet to be discovered.

The U.S. Geological Survey estimates of total United States oil resources are shown in Figure 4. The reserves are again relatively small, 52 billion barrels (B bbls) of oil which can be recovered (at a 35 percent rate of recovery) from identified oil fields. The map of Figure 5 shows the United States oil fields.

FIGURE 4

U.S. Oil Resources (in billions of barrels)

	Identified Resources	Undiscovered Resources
Recoverable	52	450
Sub marginal	290	2,100

Source: "Energy Resources of the U.S.," P. K. Theobald, S. P. Schweinfurth, and D. C. Duncan, Geological Survey Circular 650, Washington, D.C. 1972.

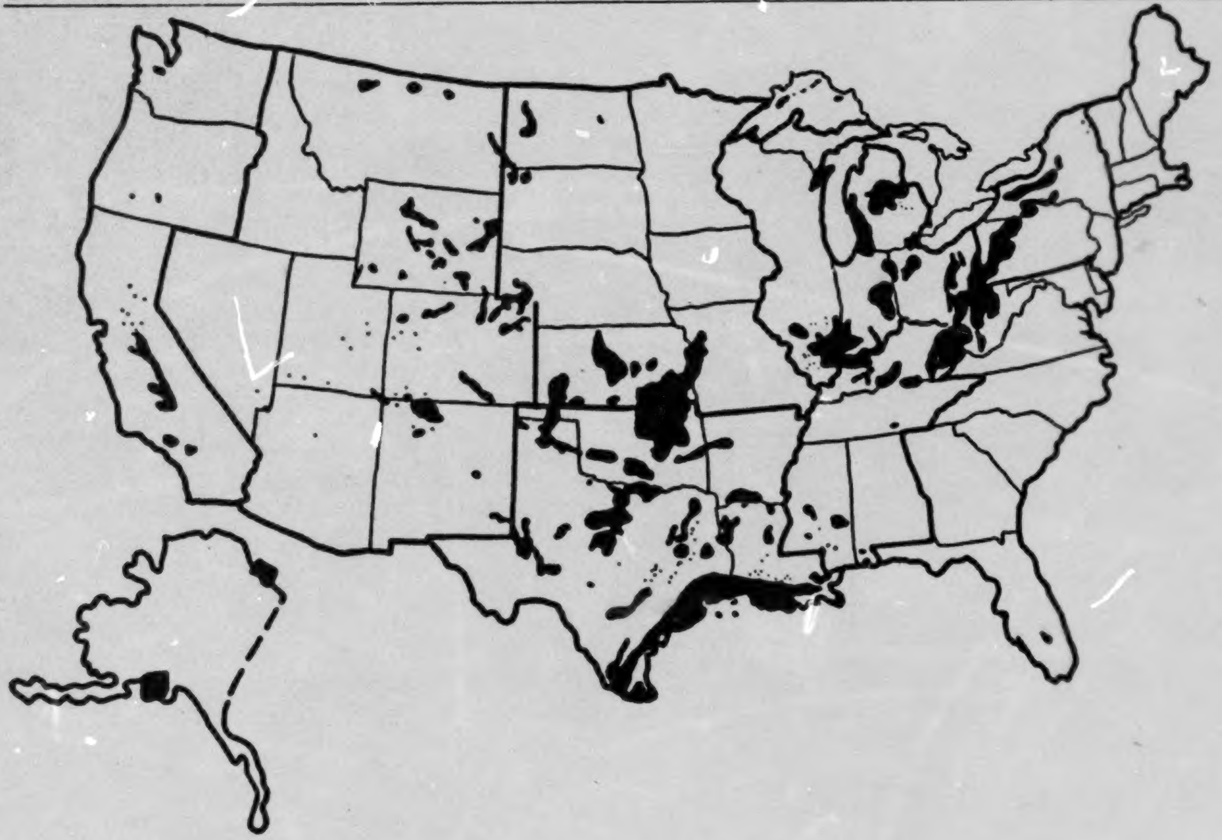
Even this oil will not be easy to extract; of the 52 B bbls of reserves, 11 B bbls are in Alaska, 6 are offshore from the United States and Alaska, and the remaining 35 B bbls are on the United States land area. Of this latter, much is accessible only to deep drilling.

Identified submarginal oil, 290 B bbls, includes all the oil left in the ground from past extraction and that which will be left by present techniques (under current prices) when the reserves are extracted.

As we did in Table 1 for coal, in Table 2 we show the total B bbls and Calories for oil of the three resource categories. The 502 B bbls is thus a fairly

FIGURE 5

Oil and Gas Fields in the U.S.



Source: Department of the Interior, U.S. Energy Fact Sheets 1971, February 1973.

TABLE 2

U.S. Oil Resources

Category	Amount (B bbls[a])		(Q Calories[a])	
Reserves[b]		52		78
U.S. Land Area	35		53	
Offshore	6		9	
Alaska	11		16	
Ultimately Recoverable[b]		502		753
Total Resource		2,892		4,340

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

(a) B bbls (billion, 10^9 barrels); Q (quadrillion, 10^{15}) Calories.
(b) A recovery factor of 35 percent is assumed.

realistic upper limit of the total amount of oil we can count on. It will take considerable improvement in technology to enable us to get more of the existing oil out of the ground and thus move some of the 290 B bbls of identified-submarginal and 2,100 B bbls of undiscovered-submarginal oil up into the "reserve" category.

Natural gas: Natural gas is formed by the same processes which form oil. It consists primarily of methane, as we have said, but contains as well smaller amounts of other similar but more complex hydrocarbons. Some of these are liquid at room temperature but become a gas at slightly higher temperatures. These fractions are generally referred to as "Natural Gas Liquids," or NGLs.

Natural gas originates with oil and in fact often helps provide the pressure which drives the oil from the well. Such gas is called "associated" gas. Since it is so much more mobile, however, gas can move through cracked rock or sandstone and collect in a separate deposit, referred to, not unreasonably, as "non-associated" gas.

Because of its mobility and its discovery with and without oil, it is extremely difficult to estimate the size of undiscovered resources. One can determine the average amount of gas formed per barrel of oil and use this to estimate the "associated" gas in oil resources. The amount of "non-associated" gas discovered per foot of drilled well fluctuates wildly from year to year and provides no reliable way to predict "non-associated" gas production.

With this admission of uncertainty, we show, in Figure 6, the natural gas resources (in trillions of cubic feet, TCF). The 170 TCF of identified but submarginal natural gas includes that 20 percent left when the identified, recoverable gas (reserves) is extracted, plus other identified quantities whose recovery is not presently feasible.

FIGURE 6

U.S. Natural Gas Resources (in trillions of cubic feet)

	Identified Resources	Undiscovered Resources
Recoverable	290	2,100
Submarginal	170	4,000

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the U.S.," Geological Survey Circular 650, Washington, D.C., 1972.

Of the 290 TCF of reserves, 30 TCF are in Alaska, 40 TCF offshore, and the remaining 220 TCF on the United States land area. As was the case with oil, those 2,[illegible]0 TCF of ultimately recoverable gas will be increasingly more difficult to find and extract. It is expected that two-thirds of this amount will be in operationally difficult areas, at deeper than 15,000 feet, for instance, or offshore, or in Alaska. This gas will therefore be much more expensive to produce.

Estimates of the total gas resource vary by a factor of three, with the highest total almost double the one we show in Figure 6. For consistency with this section, however, we will use the U.S. Geological Survey data throughout. Table 3 provides a summary of the total number of TCFs and Calories of natural gas in the three resource categories.

TABLE 3

U.S. Natural Gas Resources

Category	Amount (TCF[a])		(Q Calories[a])	
Reserves[b]		290		75
U.S. Land Area	220		57	
Offshore	40		10	
Alaska	30		8	
Ultimately Recoverable		2,560		621
Total Resource		6,560		1,710

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

[a] Trillion (10^{12}) cubic feet; Q (quadrillion, 10^{15})

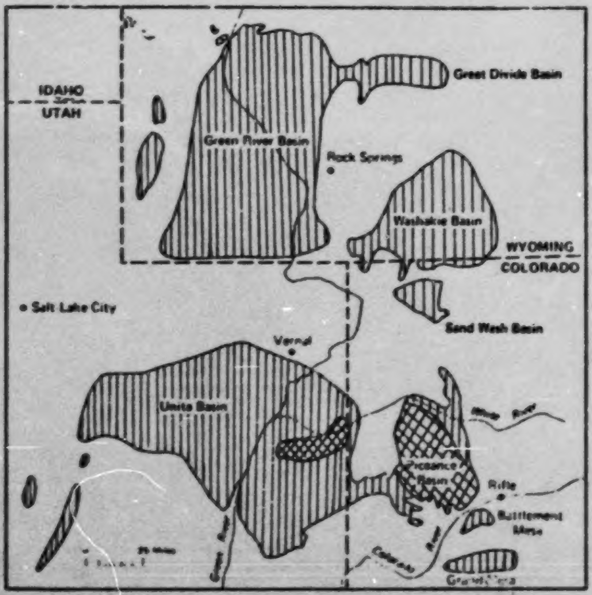
[b] Recovery factor of 80 percent is assumed.

Oil shale: A new entry on the list of resources is oil shale. Some of the petroleum formed at the bottom of the sea beds did not escape as a liquid or gas but was instead bound into the clay sediment itself which, after eons of pressure and heat, became a flaky, soft rock called shale. The amount of petroleum bound in these rocks can be quite high. Some of the shale in the deposits in pre-war Estonia average 1½ to 2 barrels of oil (63 to 84 gallons) per ton of rock and can be burned as it is. Most of the shale, however, assays at only a few gallons per ton.

The most significant United States oil shale deposits are in the Colorado, Wyoming, Utah area shown on the map of Figure 7. The richer shales shown by the darker shading have oil content of at least 25 gallons per ton and these will be the first shales mined. The various resource categories are shown in Figure 8.

FIGURE 7

Major Oil Shale Resources


Great Divide Basin
IDAHO
UTAH
Green River Basin
Rock Springs
Washakie Basin
WYOMING
COLORADO
Salt Lake City
Sand Wash Basin
Vernal
Uinta Basin
Piceance Basin
Rifle
Battlement Mesa
Colorado
Grand Mesa

▥ Area underlain by the Green River Formation

▩ Approximate extent of selected minable seam in the Mahogany Zone (at least 30 feet thick and averaging at least 30 gal./ton).

Source: U.S. Energy Outlook, National Petroleum Council, December 1972.

FIGURE 8

U.S. Oil Shale Resources (in billions of barrels)

	Identified Resources	Undiscovered Resources	
		Extension of known resources	Undis. & Unappraised
Recoverable	0	0	0
Paramarginal	160 600(a)	850	500
Submarginal	1,600	2,500	20,000

(a) Oil content greater than 25 gallons barrels per ton.

Source: "Energy Resources of the U.S.," P. K. Theobald, S. P. Schweinfurth, and D. C. Duncan, **Geological Survey Circular 650**, Washington, D.C. 1972.

The recovery of oil from oil shale is just beginning to be economically feasible. The rock must be mined, crushed, and then heated to drive out the oil. At the time of preparation of Figure 8, the expected cost of recovery of this oil, about $6 per barrel, was too high to allow it to compete with cheap Mid-eastern and South American oil. The tremendous price increases in 1973-1974 allow us to change the designation of the 160-600 B bbls shown as "paramarginal" in the original U.S. Geological Survey presentation to "identified recoverable" in our version. We should still caution, however, that large-scale processing of oil shale is only just beginning and it is not at all certain that we should really consider oil from shale as a "reserve." We continue in this cautious interpretation in Table 4 and include under "ultimately recoverable" only the 600 plus 850 B bbls from the "identified" and the "extension of known resources" categories of Figure 8.

TABLE 4

U.S. Oil Shale Resources

Category	Amount (B bbls(a))	(Q Calories(a))
Reserves(b)	160-600	240-900
Ultimately Recoverable	1,010-1,450	1,520-2,180
Total Resource(c)	5,110-5,550	7,670-8,330

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," **Geological Survey Circular 650**, Washington, D.C., 1972.

(a) B bbls (billion, 10^9) barrels); Q (quadrillion, 10^{15}) Calories.

(b) Oil content greater than 25 gallons per ton and deposits greater than 10 feet thick. One hundred percent recovery assumed for lack of relevant experimental data.

(c) Includes only "identified recoverable" and "extension of known resources" from Figure 1-6.

Tar sands: There is a fourth, rather small potential source of oil similar to the shales. In this case the oil, rather than impregnating shale rock, has been formed in sand and binds this material together. It must be processed in a manner similar to shale, mined and then heated. There is essentially no United States experience with tar sand (although the Canadians are mining tar sands in Alberta), so the only category which it can be put into at present is that of total resource. The 18-28 B bbls resource shown in Table 5 is an estimate of the content of some known deposits in Utah.

TABLE 5

U.S. Tar Sands Resources

Category	Amount	
	(B bbls[a])	(Q Calories[a])
Total Resource[b]	18-28	27-42

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

[a] B bbls (billion, 10^9 barrels); Q (quadrillion, 10^{15}) Calories.
[b] No estimate of recovery factor.

NUCLEAR FUELS

There is much of interest to say about nuclear reactors, about how they work and their advantages and disadvantages compared with other sources of power. In this discussion, we will limit ourselves to an estimate of the size of the fuel stockpile and discuss the process of using this fuel, only where it is essential to understanding that estimate.

Uranium: The most important nuclear fuel is uranium, one of the heaviest of the elements. It is a radioactive element and, in fact, the uranium prospectors, so much in evidence in the 1950s, used detectors of radioactivity, "Geiger counters," to look for it.

Uranium is a rare mineral. On the average it occurs in a ratio of 2 parts per million (ppm) in the earth's crust. It occurs in greater concentrations in certain rocks and ores; this concentration ranges from 4 ppm in granite, to 70 ppm in the Chattanooga shales, to 2,000-3,000 ppm in the uranium ores which are mined commercially.

If the "breeder reactors" come into being, some of the dilute uranium ores, even the Chattanooga shales and granite, could be used as fuel. At present, however, we will explore the size of the resource in terms of the richer ores.

Uranium is mined and refined to a uranium oxide, U_3O_8. The resources are traditionally expressed in terms of tons of U_3O_8 and we will follow this practice. In assigning the amounts of identified ore to the various categories, the price for the recovery of the U_3O_8 is the dominant factor. In 1970 the ore was produced for $8 per pound or less and that price is chosen for the cut-off between the recoverable and the submarginal categories. In this latter category only uranium that can be produced for less than $15 per pound is listed. As the price of electricity increases, more expensive ores can be added to the resource estimate. This will be especially true if the "breeder reactor" enters the picture, for then the cost of the ore will be only a small part of the total cost of electricity.

Figure 9 shows the U.S. Geological Survey estimate of uranium resources, and Figure 10 gives the location of the most important deposits. To the recoverable and submarginal categories already discussed, we add a third category, "by-product." There are two existing processes that produce uranium as a by-product. One of these is copper mining and the other the mining and refining of phosphate rock in the manufacture of fertilizer. It is estimated that at least 1,000 tons per year of U_3O_8 at under $10 per pound could be obtained from the copper ores and that similar amounts could be obtained from the phosphate rock. It must be pointed out that these prices for the U_3O_8 assume that the recovery of uranium is part of the mining-refining process for these ores. If the uranium is thrown away, as it is now, it is removed from the by-product category, and its cost of recovery increases.

FIGURE 9

U.S. Uranium Resources (in thousands of tons)

	Identified	Undiscovered (In known districts)	(In unknown districts)	
Recoverable[a]	250	500	250	
Submarginal[b]	200	400		
By Product[l,]	1,000			

The summary, Table 6, is presented in terms of price as this is the most important determinant of the recoverable or submarginal classification. The conversion of tons of U_3O_8 to Calories, however, cannot be made without some reference to what takes place in the reactor. For the present we will base our results on two pieces of information (from the Atomic Energy Commission -- Nuclear Regulatory Commission). A 1,000 megawatt (million watt, Mw) conventional reactor plant operating at 75 percent capacity uses about 130 tons of U_3O_8 per year. During that year it will generate 6.6 B kw-hrs of electricity. Since, at the present time, electric energy is the only output of the reactor, we will use for our conversion 130 tons of U_3O_8 as the equivalent of 6.6 B kw-hrs (5.7 T Calories) of energy or 44 B Calories per ton. The energy equivalents of the various classes of uranium resources shown in Table 6 use this conversion.

TABLE 6

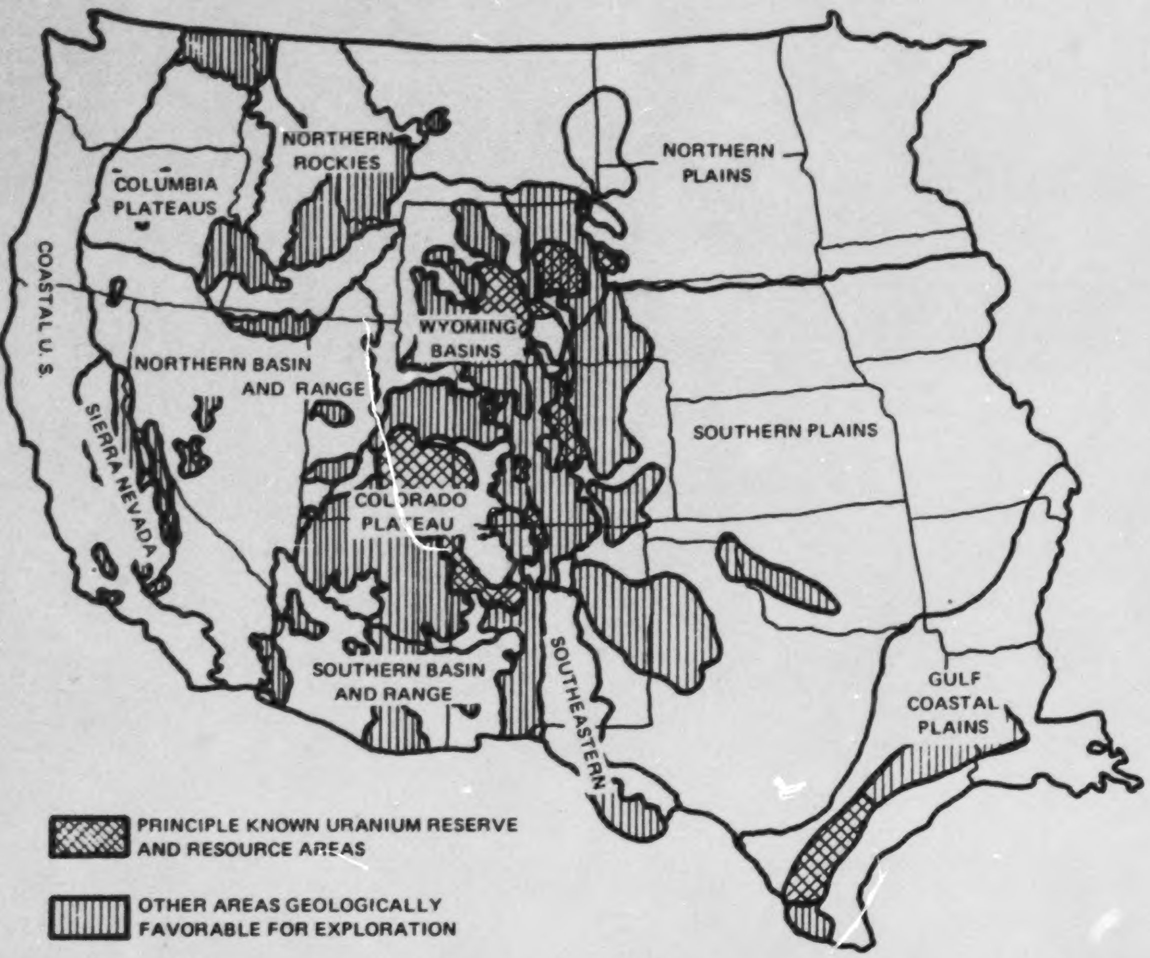
U.S. Uranium Resources

Category	Amount (Millions of tons)	(Q Calories[a])
Reserves (less than $8 per pound)	250	11
Ultimately Recoverable (less than $8 per pound)	1,000	44
By-product (less than $10 per pound)	1,000	44
Total Resource (less than $15 per pound)	2,600	114

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

FIGURE 10

Uranium Resources Western United States


NORTHERN ROCKIES
COLUMBIA PLATEAUS
COASTAL U.S.
NORTHERN BASIN AND RANGE
SIERRA NEVADA
WYOMING BASINS
COLORADO PLATEAU
SOUTHERN BASIN AND RANGE
SOUTHEASTERN
NORTHERN PLAINS
SOUTHERN PLAINS
GULF COASTAL PLAINS
▩ PRINCIPLE KNOWN URANIUM RESERVE AND RESOURCE AREAS
▥ OTHER AREAS GEOLOGICALLY FAVORABLE FOR EXPLORATION

Source: U.S. Energy Outlook, National Petroleum Council, December 1972.

What is surprising is the relatively small size of the uranium resource. It must be remembered, however, that this computation of Calories is based on the generation of electricity in the present, not very efficient, "light water reactor," whereas the other fuels are converted to Calories at full value. The price factor also enters in. We have included only the total resource available at less than $15 per pound. If we were to move the scale up to $30 per pound, we could add another 1,300,000 tons to the total resource. Even with this explanation, Table 6 reminds us that uranium is also a finite resource. It has, however, a potential of extension the others do not have. The present reactors use a rare form of uranium, the isotope U-235. U-235 is present as less than 1 percent of the total amount of uranium. The rest of the uranium, the isotope U-238, is not used. If the breeder reactor works and is judged safe enough to use, it can convert the common U-238 to fuel as well and the resources tabulated in Table 6 will be multiplied by perhaps a factor of 50. The uranium resources then begin to rival coal in energy content.

TABLE 7

U.S. Thorium Resources (ThO_2)

Category	Amount (Thousands of tons)	
Reserves (identified and less than $10 per pound)		65
Lemki Pass	47	
S.E. United States	18	
Ultimately Recoverable (identified and inferred at less than $10 per pound)		400
Lemki Pass	382	
S.E. United States (no additional discovery as yet)	18	

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

Thorium: The other naturally occurring nuclear fuel is thorium. Thorium is also a rare material; a metal like uranium, it is also radioactive. It is more abundant than uranium, averaging about 12 ppm in the earth's crust as against uranium's 2 ppm.

Thorium is used only in one existing reactor, the high temperature gas reactor (HTGR) at Peach Bottom, Pennsylvania, where it makes up only 10 percent of the fuel load. In the HTGR thorium is converted into a uranium isotope, U-233. For now it is sufficient to say that thorium is a submarginal fuel which waits on further technological development for full use.

A large supply of thorium awaits utilization. In the Northwest, at Lemki Pass in Idaho and Montana, some 47,000 tons of thorium oxide ore have been identified and another 335,000 tons is inferred there. There are also deposits in the Southeastern United States.

Table 7 shows recent AEC, estimates of thorium ore available at less than $10 per pound. These are minimal estimates since very little exploration for thorium has actually taken place. ThO_2 is not converted to Calories in this table, as the conversion process is still too new to give us a reliable guide. Since the energy ultimately available from a pound of thorium is about the same as is available from a pound of uranium, we see by reference to Table 6 for uranium that there is also much energy waiting for us in the thorium deposits.

THE OTHER SOURCES

We have now summarized the extent of our resources of fossil fuels, and have also looked at the nuclear fuels we may be counting on more and more heavily in the next several decades. We will finish up this tabulation by looking briefly at five other sources of energy of varying importance.

Energy from the tides: The United States cannot expect much help from the tides. The amount of energy in them is fairly small. The practical restrictions are even greater. There must be a tidal change of 15 feet or so to make such an operation worth considering; there must be a considerable flow of water, and so on. The only serious study of such a project in the United States has focused on the Passamaquoddy Bay between Maine and Canada. Current studies do not indicate a reasonable commercial feasibility.

Geothermal energy: The steam created by conduction from the earth's molten interior is an old, new source. Steam from the Lardello, Italy, geothermal field has been turning electric generators since 1904. We did not begin to use this free energy in this country, however, until 1960 and even now our one operating field, California's Geysers, has a total capacity of 500 Mw, only about 0.1 percent of the nation's total generating capacity. This capacity, however, is now the largest of any of the world's geothermal generating systems.

From such meager experience with geothermal energy, resource estimates are very uncertain. The U.S. Geological Survey estimates are shown in Figure 11. A map showing the clustering of these resources in the far West is shown as Figure 12.

FIGURE 11

U.S. Geothermal Resources (in Q [10^{15}] Calories)

	Identified Resource	Undiscovered Resources
Recoverable	2,250	
Sub-Marginal	> 10,000,000	

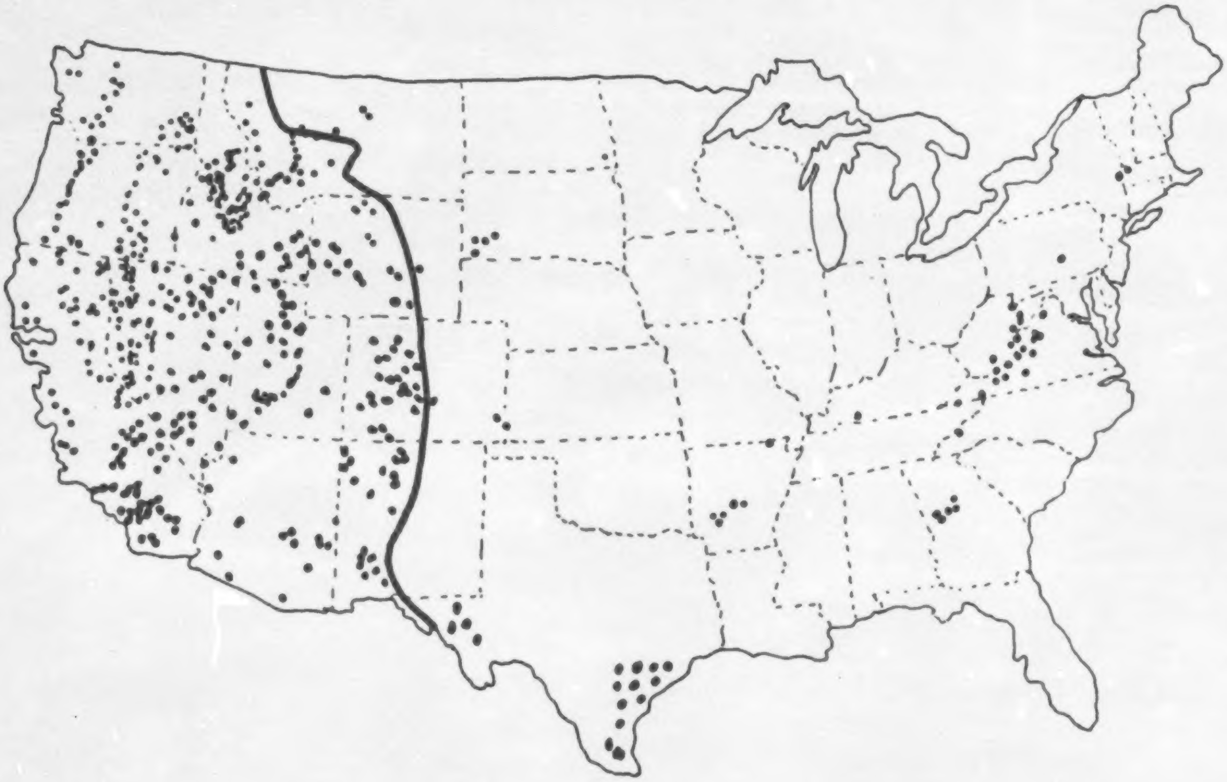
Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the U.S.," Geological Survey Circular 650, Washington, D.C., 1972.

The resource estimate shown in Figure 11 differs from the others in that it is given directly in Calories. This is appropriate because this resource is already in the form of heat energy. In arriving at the 2,250 Q Calories, the total amount of heat energy available in steam from the Geysers and other known areas (excluding those in Our National Parks) is reduced by the 15 percent efficiency with which this steam is produced. There are about 2,000 Q Calories of measured resource and 3,000 Q Calories inferred in the Geysers alone, and another 10,000 Q Calories inferred or measured elsewhere. Thus, from this total of 15,000 Q Calories, we can only expect to extract 2,250 Q Calories.

The much larger submarginal figure of greater than 10,000,000 Q Calories is of a different sort altogether. The Geysers turbines use "dry steam," steam that is so hot there is no water mixed with it, and very little in the way of other impurities. Such steam can be piped directly to the turbines with only some simple screening to remove abrasive particles. The recoverable resources estimate is also restricted to dry steam fields. If we also include steam that is not so hot, hot water, and even hot rocks at a reasonable depth of 10 kilometers (about 6 miles), we get the much larger submarginal estimate. To use these forms of geothermal energy will take new technology.

FIGURE 12

Location of Geothermal Resources in the U.S.



Solid Waste: The conversion to energy of the billions of tons of solid waste produced annually in the U.S. together with the recycling of noncombustibles (glass, aluminum, ferrous materials) would dramatically reduce environmental pressures associated with waste disposal and supply a large fraction of our energy needs.

However, because the production of waste materials - particularly agricultural wastes - is scattered over a wide area, most experts believe that at best solid wastes should not be expected to contribute more than two or three percent of our national energy supply.

Water power: The oldest of the sources of energy we have been considering here is water power. Water wheels were put into use by the Romans at about the time of Christ and were, with wind, a source of power long before the steam engine.

Except for a few grain mills, in this country we use water exclusively for the generation of electricity, to which it contributes about 15 percent of the total. From stream-flow data it is found that the production of this 15 percent already uses about a third of the total potential energy from flowing water available to us. Much of the remaining potential is protected by legislation such as the Wild and Scenic Rivers Act. The Federal Power Commission predicts that the 51,600 Mw of 1970 hydropower generating capacity will increase to 82,000 Mw by 1990. There is not much potential for increase beyond that.

Solar energy: Solar energy is essentially an inexhaustible source. It is capable of meeting a significant portion of the nation's future energy needs with a minimum of known adverse environmental consequences.

If Solar energy provided one percent of the nation's energy needs by 1983, this would conserve approximately 100 million barrels of oil per year.

Total electrical energy consumption of the United States is equivalent to the solar radiation falling on only some 400 square miles of desert. If this Solar Energy could be tapped with only 5% efficiency, 8,000 square miles (a 90-mile square) of desert would be required to supply the energy needs of the U.S.

Certain minerals used in the manufacture of solar energy systems may be in short supply and thus limit the use of the sun's energy. A great deal of solar energy research will be required to develop this energy source economically.

Wind power: The wind blows as a result of solar heating, however, wind is even more variable than solar power. To tap wind power requires windmill-sail areas much larger than solar panel areas to generate equivalent amounts of electrical power. The steady winds blow high in the atmosphere. . . research is needed to develop the technology to harness the available power. Copper may be in short supply for winding coils of the generating devices required for wind produced electricity.

TABLE 8

U.S. Energy Stockpiles (Q Calories)[a]

	Category	
Fuel	**Reserves**	**Ultimately Recoverable**
Coal	2,380	2,380[b]
Oil	78	753
Natural Gas	75	621
Uranium	11	88
Oil Shale	240-900	1,520-2,180
Total	2,784-3,444	5,382-6,022

Source: P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan, "Energy Resources of the United States," Geological Survey Circular 650, Washington, D.C., 1972.

[a] Q (quadrillion, 10^{15}) Calories.

[b] No additional discovery is expected but new recovery techniques could add significantly to this total.

[c] Includes "by-product" at under $10 per ton (See Table 2-7).

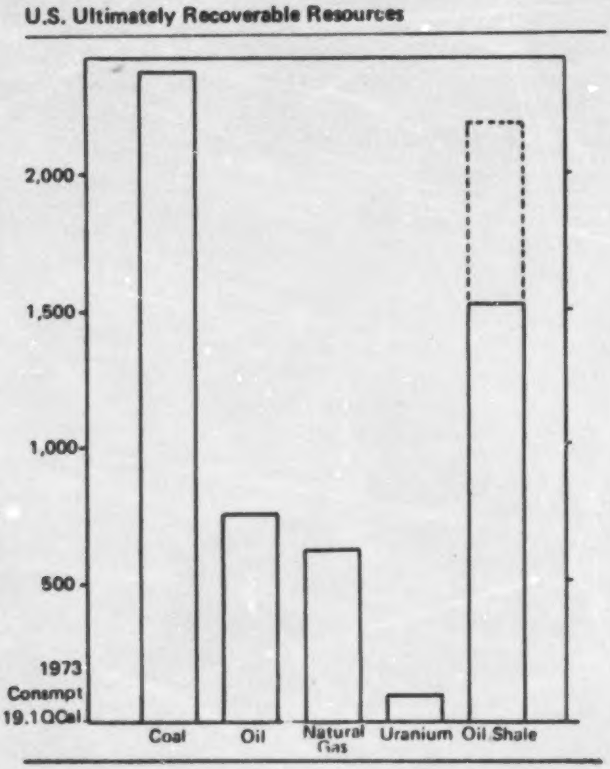
UNITED STATES ENERGY STOCKPILES

Table 8 summarizes the resource information we have just discussed; the same data is presented graphically in Figure 13. These presentations emphasize again the dominance of coal in the resource picture; it is 30 times as abundant in the reserves category as oil or natural gas. Oil shale, in fact, is the next largest reserve, but the practical availability of that fuel is yet to be tested. The actual amount of energy from this source we will extract and consume will, in all likelihood, be considerably smaller than the amount we show as a reserve in Table 8.

SUMMARY

The energy resources we have considered in this chapter are of two forms. Some are best described as energy flows - power - and others as stockpiles of stored energy. Solar and tidal energy fit into the first category; we have somewhat arbitrarily put geothermal energy, along with chemical and nuclear energy, into the latter.

FIGURE 13


U.S. Ultimately Recoverable Resources

These energy flows, or continuous sources as we sometimes term them, are all large enough to make useful contributions to our needs. One of them, solar power, could take care of us now and in years to come. However, we have developed little in the way of technology to allow use of these forms of free power and depend almost exclusively on energy from our depletable stockpiles. It is on the assessment of these stockpiles, for the United States and the world, that we focused this section.

The relevant data are summarized graphically in Figure 13. In the United States coal is the largest stockpile. There is at least 10 times more coal (30 times more in the U.S.) than oil or gas, although if the production of oil from oil shale becomes practical, this resource will rival that of coal. We also found, somewhat surprisingly, that the stockpile of uranium, due to our present inefficient conversion of its energy to electrical form, is not a large one. Improvement in conversion techniques and increased exploration may possibly change that part of the picture.

The data of this section give us some idea of the size of our energy stockpiles. The next question would seem to be, "How long will they Last?" Before we can answer we must have some information about the use of these fuels, and that will be the subject of the following section.

[1] "Energy Resources of the United States" P.K. Theobald, S.P. Schweinfurth, and D.C. Duncan. Geological Survey Circular 650. Washington, D.C. -1972.

*Note

The section, "U.S. Energy - Where does it come from? How much do we have?," has been developed from selected materials from the NSTA Energy - Environment Source Book, J.M. Fowler, 1975. This source book, the Energy-Environment Materials Guide, and the Energy Environment Mini-Unit Guide can be purchased from NSTA, 1742 Connecticut Avenue, Washington, D.C. 20009

WHAT ARE THE ROOTS OF OUR ENERGY PROBLEM?

*The vast reserves of coal in the United States amount to three times the energy contained in the Middle East's oil reserves, and currently account for more than 90 percent of U.S. proven energy reserves.

*Yet over the last 75 years, the United States has switched from using coal for over 90 percent of its energy needs to depending on oil and gas for 75 percent.

*Thus, the Nation depends upon its least abundant energy resources to provide most of its energy needs.

*The United States has a growing dependence on imported energy, the availability and price of which are controlled by a few Middle East countries.

*Our task between now and 1985 is to find and develop more oil and gas, to stimulate conservation, and convert our economy to the more abundant resources, such as coal and nuclear power.

*In the post-1985 period, our task is to develop new technologies that can dramatically expand our economically usable reserves of shale oil and uranium, and to make greater use of non-depletable resources, such as solar and geothermal energy.

HOW DID WE BECOME SO VULNERABLE TO OIL IMPORTS?

*The availability of inexpensive imported oil served as a disincentive to domestic production, which peaked at 9.6 million barrels per day (M bbls.) in 1970, has been declining ever since, and now stands at 8.2 M bbls.

*Meanwhile, petroleum demand grew at an annual rate of 4.6 percent in the 1960's and early 1970's, in response to low prices, air pollution restrictions on coal use, and the growing use of automobiles.

*The combination of declining domestic production and rising demand led to a rapid growth in imports:

- From 1.8 M bbls., or 19 percent of consumption, in 1960.
- To 3.4 M bbls., or 23 percent of consumption, in 1970.
- To 6.0 M bbls., or 37 percent of consumption, in 1975.

*The Arab oil embargo in 1973/74 demonstrated that the United States is vulnerable to severe supply disruptions and oil price increases.

*Today, the United States spends about $27 billion, or $125 per person, for imported oil, as compared with about $3 billion, or $15 per person, in 1970.

HOW MUCH ENERGY WILL THE NATION CONSUME?

*Energy demand grew at a rate of 3.6 percent in the 20 years before the 1973 embargo, and in 1975 the United States consumed about 73 quadrillion Btu (quads).

-- Electricity consumption grew at twice the rate of all energy demand (about 7 percent per year).

*By 1985, as a result of higher prices, energy demand will be much lower - even with economic expansion - than if historic growth rates had continued.

-- With a continuation of current oil prices (about $13 per barrel in 1975 dollars), demand will be 98.9 quads in 1985 - a 2.8 percent growth rate.

-- Electricity will still grow about twice as fast as overall energy demand, but at reduced levels of 5.4 percent per year.

-- Consumption will gradually shift from oil and gas to coal and nuclear power.

*If world oil prices decline to $8 per barrel, or if oil and gas prices are regulated substantially below market prices, energy demand will grow faster - at an annual rate of between 3.0 and 3.2 percent.

*The greatest reductions in energy growth will be in the Household/Commercial and Transportation Sectors, which will respond most sharply to higher energy prices.

HOW WILL THE NATION MEET ITS GROWING ENERGY DEMANDS BY 1985?

*Total domestic supply is forecast to increase by 40 percent between now and 1985, with all major fuels playing a large role:

-- Coal production could increase to over one billion tons, from current levels of 640 million tons.

-- Oil production could reach 13.9 M bbls. (including natural gas liquids), if Outer Continental Shelf leasing is strongly pursued and market prices prevail.

-- Natural gas production could reach 22.3 trillion cubic feet (Tcf) if new gas prices are deregulated, but could be 17.9 Tcf under current regulations.

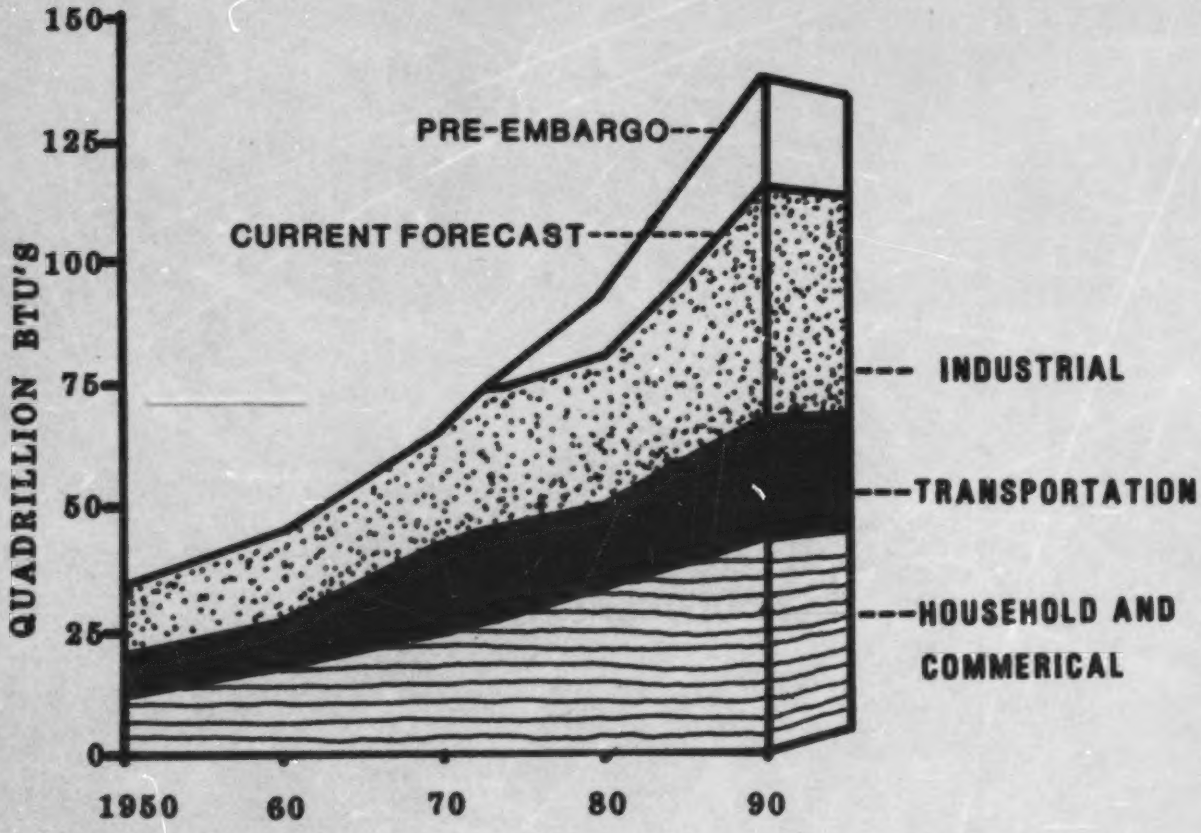
-- Although nuclear power has experienced significant delays, it could grow from current levels of 8.6 percent to about 26 percent of electricity generation.

-- Emerging technologies such as solar, geothermal and the conversion of coal into oil or gas, will be important in the post-1985 period, but will not produce much energy in the next ten years.

*Each of these supply increases, while technically and economically feasible, requires significant growth of the energy producing sectors and will not be forthcoming unless pricing and government regulatory policies encourage it. Institutional barriers and policy uncertainty will also delay development.

*If one or more domestic energy sources do not achieve these projected levels, imports will make up the shortage because other domestic fuel sources could not compensate for the loss.

HOW MUCH ENERGY WILL THE NATION CONSUME ?



HOW MUCH ENERGY CAN BE SAVED?

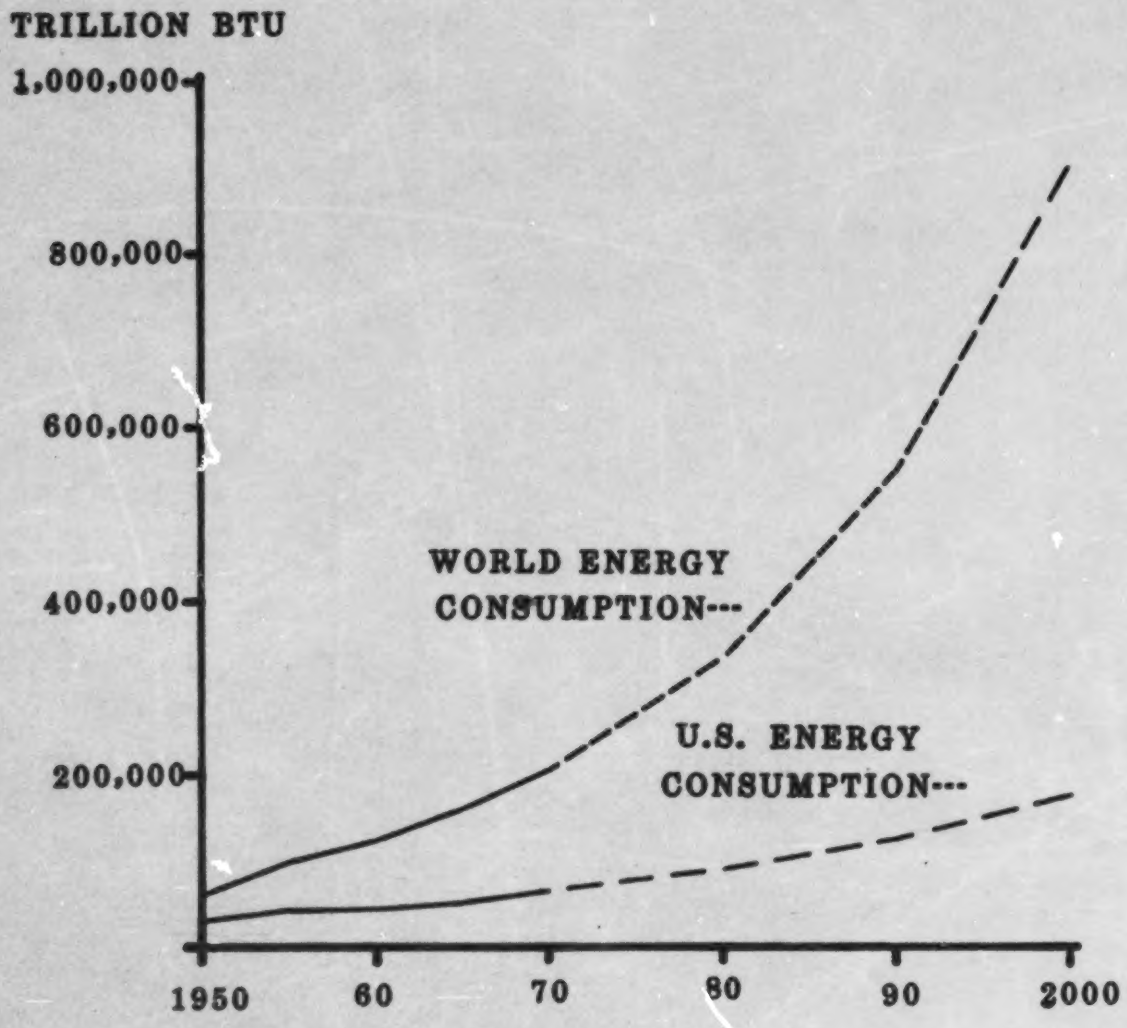
*Higher energy prices should significantly cut energy demand growth during the next 10 years, reducing the growth rate to 2.8 percent from the historical rate of 3.6 percent.

*An active conservation program could further reduce energy demand by the equivalent of 3 million barrels per day, reducing the annual energy growth rate to 2.2 percent through 1985.
-- Savings could be achieved in all the major sectors: residential,

commercial, industrial, and transportation.

-- Actions which improve energy efficiency of automobiles, homes, and office buildings would have the greatest impact in the next 10 years.

*While conservation can reduce energy demand, it does not appear feasible to cut the growth rate to zero or to obviate the need for expanding existing supplies of energy.



WHAT WILL OIL IMPORTS BE BY 1985?

*Imports will continue to increase in the next 2 years, until Alaskan oil production begins.

-- There is little that can be done to cut imports through 1977, although conserving energy and increasing oil recovery in existing fields will provide some help.

*We have much greater ability to cut imports by 1985, if appropriate policy actions are taken:

- If oil and gas prices are regulated at low levels, imports could reach 13.5 M bbls. in 1985.
- With gradual deregulation of oil and gas prices, and a continuation of current world oil prices, imports could drop to 5.9 M bbls., slightly below today's level.
- A maximum effort to increase supply and cut demand could reduce imports to about 1 M bbls., making the United States invulnerable by 1985.

*By 1990, however, imports could increase as domestic production from older fields again declines. This decline will need to be offset by the growing use of nuclear power, synthetic fuels, solar, and other emerging technologies.

WHERE WILL NEW OIL SUPPLIES COME FROM?

*Domestic crude oil production could increase to 12.3 M bbls. in 1985 (From 8.8 M bbls. in 1974), if today's market prices are allowed to stimulate domestic production and if an aggressive OCS leasing and development program is followed.

*While total production will exceed today's levels, oil supply from existing onshore reserves could decline to 2.4 M bbls. by 1985, as older fields are depleted.

- But, more intensive use of secondary and tertiary recovery in current fields and new discoveries onshore can keep onshore production about constant.

*If the current OCS leasing and development schedules are followed, OCS production could about double by 1985, to about 2.3 M bbls.

*Alaska will be the greatest new source of production, increasing to about 2.4 M bbls. by 1985.

HOW DO RESERVES AFFECT DOMESTIC PRODUCTION?

*The amount of oil we discover and produce depends on how much oil is in the ground (reserves) and whether oil prices are high enough to justify its production.

*If oil prices remain at current levels and the Federal Government's best estimate of known and expected reserves proves correct, domestic production could reach 12.3 M bbls. (or 13.9 M bbls. including natural gas liquids) by 1985 and would begin to decline in the late 1980's.

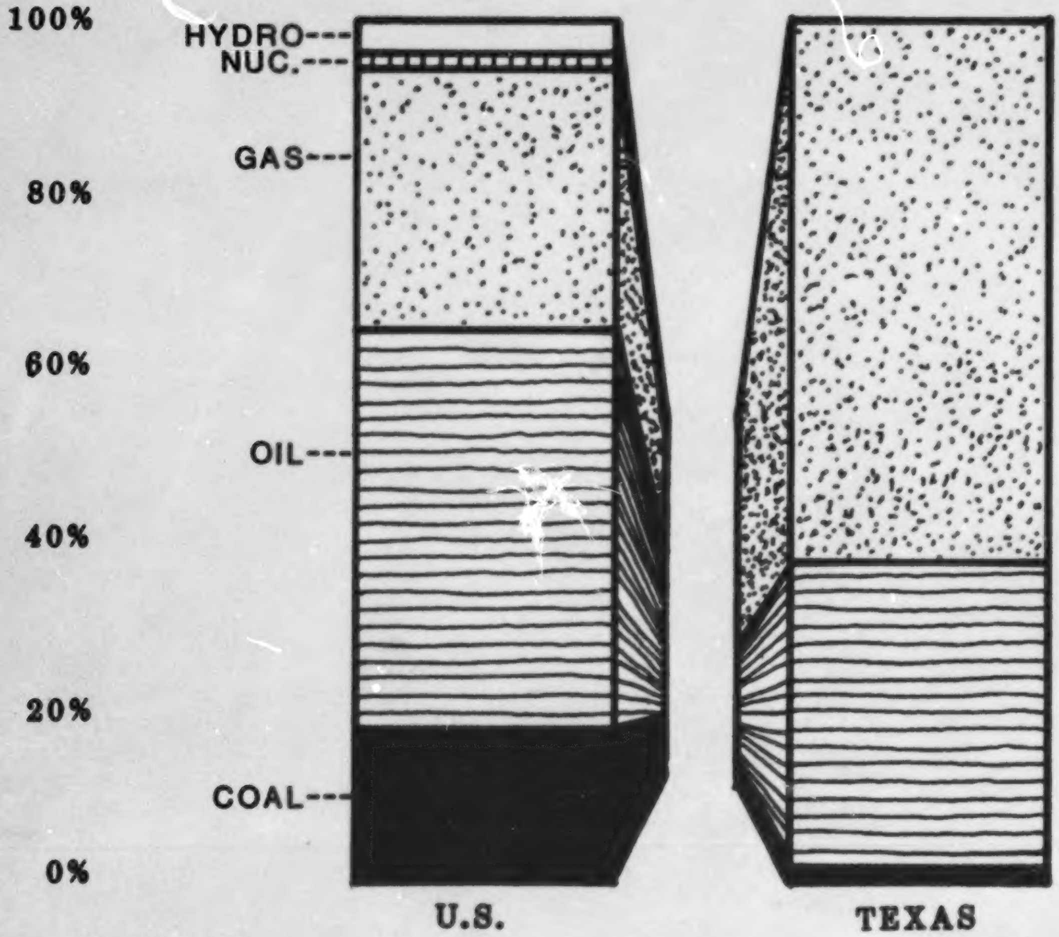
*If world prices fall to $8 per barrel or domestic prices are regulated over a long period, production is never likely to be much above today's levels, and will decline again in the early 1980's. Crude production could be as low as 8.3 M bbls. in 1985 under these circumstances.

-- This decline will occur because the more expensive enhanced recovery techniques and some frontier area production, such as that from Alaska, would not be economic at lower prices.

*It is highly uncertain how much oil remains to be found and produced:

-- If reserves are much lower than expected, production could not peak much above historic levels and would decline rapidly thereafter, even at high world oil prices.
-- If reserves are much higher than expected, oil production could be maintained at least at today's levels for many years.

ENERGY RESOURCE CONSUMPTION



1974

WILL NATURAL GAS PRODUCTION CONTINUE TO DECLINE?

*Natural gas production can be expected to decrease during the next few years, but then increase to 22.3 TCF in 1985 if prices are deregulated (as compared with 20.1 TCF in 1975).

- Most of the new gas production will come from the Gulf of Mexico and intensive production from onshore fields.
- If OCS leasing is accelerated and resource availability proves more favorable than expected, natural gas production could reach 25.5 TCF in 1985.

*If present regulations continue, natural gas production could decline to 17.9 TCF in 1985. The lower the price, the more rapid will be the decline in natural gas exploration and production.

*Because of limited reserves and uncertain supplemental gas supplies, natural gas production is likely to peak in the 1980's and probably decline again.

*Supplemental gas supplies could play an important role in the 1980's and later:

- Gas from Alaska could supply over 1 TCF before 1985, if needed transportation systems are completed.
- Liquefied natural gas could supply about 2 TCF by 1985.
- If financial incentives are provided, over 1 TCF of synthetic gas could be delivered by 1985, and this source could supplement dwindling supplies of naturally occuring gas in the post-1985 period.

WHERE WILL NEW COAL PRODUCTION COME FROM?

*Coal production is projected to increase from 603 million tons in 1974 to 1040 million tons in 1985.

- Coal production will increase more slowly if long-term utility demand is uncertain and if major environmental and transportation issues are unresolved.
- More coal probably could be produced, but will not be because its markets are limited primarily by the growth in electric power and synthetic fuels.

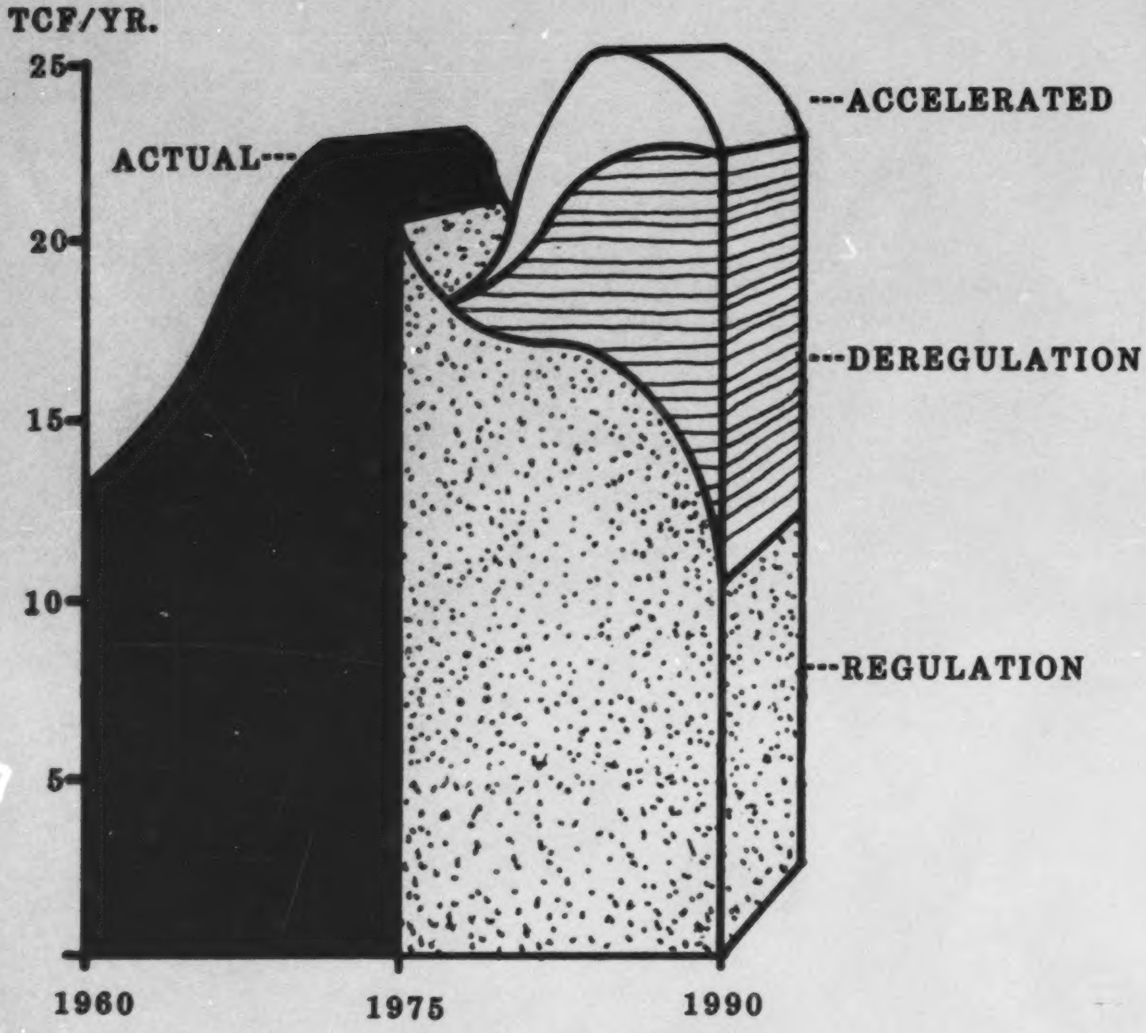
*The major expansion of production will occur in the Western regions, increasing from 92 million tons in 1974 to about 380 million tons in 1985.

- Western coal production will continue to be mainly surface mining.

*Eastern mining could expand by about 30 percent.

- Underground mining should reverse recent trends and increase more than surface mining in the East, since low-cost surface reserves are being depleted.

WILL NATURAL GAS PRODUCTION CONTINUE TO DECLINE ?



WHAT WILL BE THE SOURCES OF ELECTRICITY IN THE FUTURE?

*Electricity could continue to grow at about twice the rate of total energy demand; but its growth rate will be reduced to about 5.4 percent, compared with its historical rate of about 7 percent.

*The use of natural gas and oil to generate baseload electricity could be phased out due to higher prices, and be replaced with less expensive nuclear and coal-fired power.

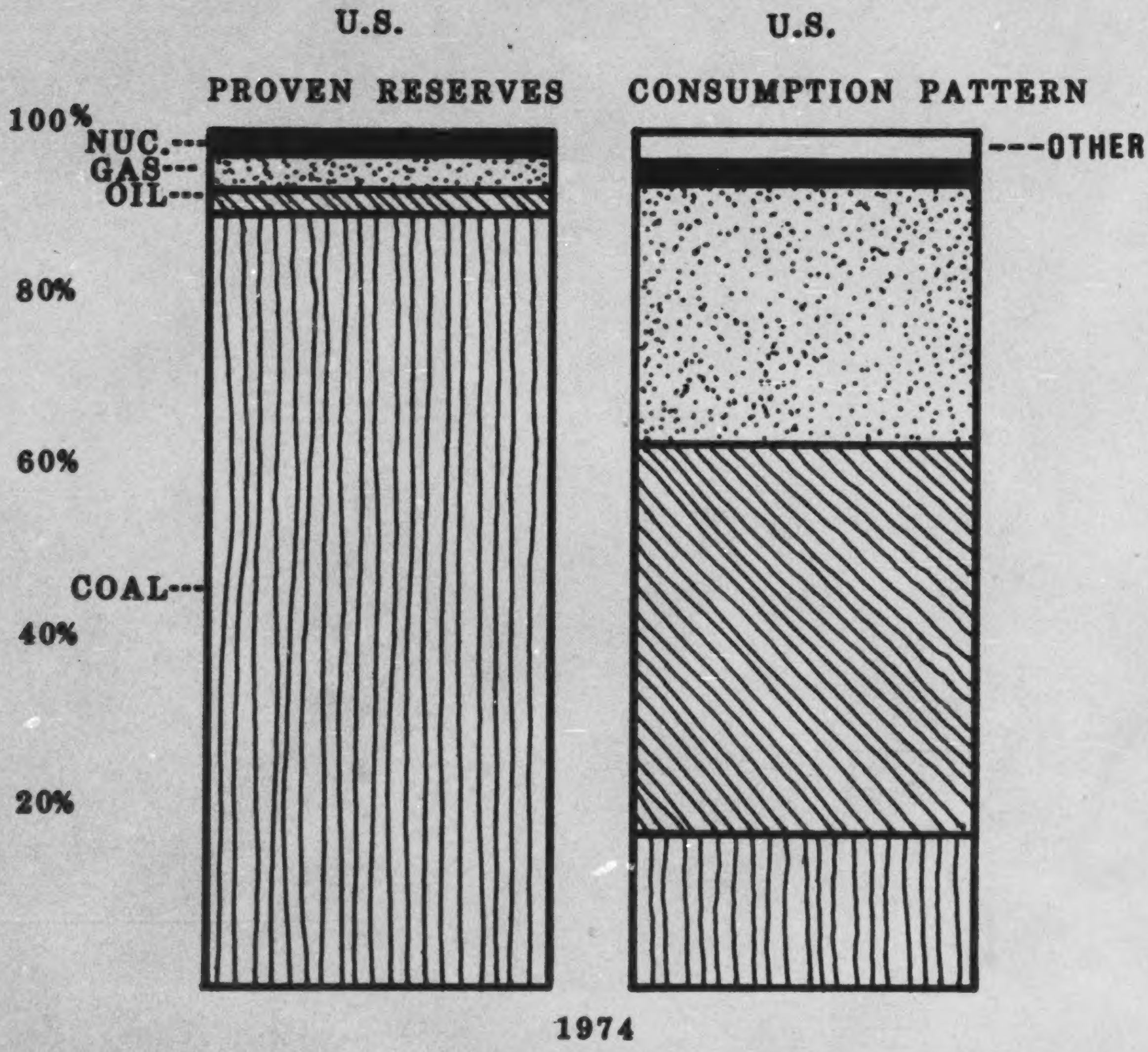
*Coal's use in electric generation could increase by 77 percent in the next 10 years.

- Over 700 million tons of coal could be used to generate electricity in 1985, as compared with 392 million tons in 1974.

*Nuclear energy could represent about 26 percent of electric power generation in 1985, as compared with 8.6 percent in 1975.

- However, nuclear power accounts for a 30 percent smaller contribution than previously projected, reflecting actual cancellations and deferments caused by reductions and uncertainty in demand growth, financial difficulties, and licensing delays.

*Electricity will represent a continually increasing share of energy in the future, rising from 28 percent in 1974 to 37 percent in 1990.



HOW MUCH CAN NEW TECHNOLOGIES CONTRIBUTE?

*Solar, geothermal, and synthetic fuels will make only a small contribution to domestic energy supplies by 1985 (about 1 percent).

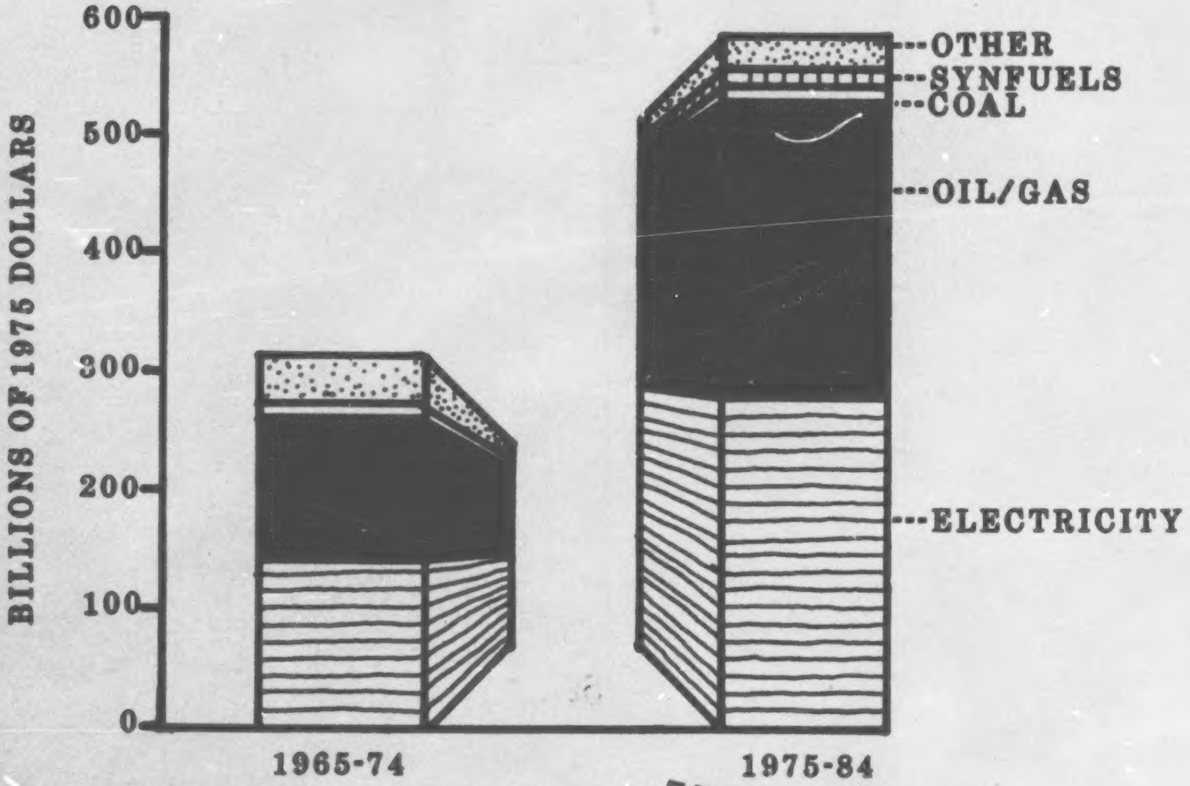
*The major contribution from solar, geothermal, and synthetic fuels will not be felt until after 1990.

*The technology for these sources exists, but must be proven economically viable on a commercial scale. It will take several years to build the first full-size plants; hence a large industry will not be possible during the next 10 years.

*It is likely that few, if any, synthetic fuel plants will be built by 1985 without Federal financial assistance.

*Unless commercial size plants are started now and proven economic by 1985, it will not be possible for these new sources to replace dwindling supplies of oil and gas in the post-1985 period.

HOW MUCH WILL
ENERGY SUPPLY
INVESTMENT COST ?



HOW MUCH WILL ENERGY SUPPLY INVESTMENT COST?

*Energy investments in the United States will be about $580 billion (in 1975 dollars) in the next 10 years.

-- While this investment seems large, it is about 30 percent of fixed business investment, which is energy's historical share.
-- In certain sectors, such as utilities, large demands will be placed on the capital markets.

*Oil, gas, and electric utility capital spending will almost double in the next 10 years.

*The largest portion of the energy investment will be in the electric utility sector which could account for 47 percent of the total.

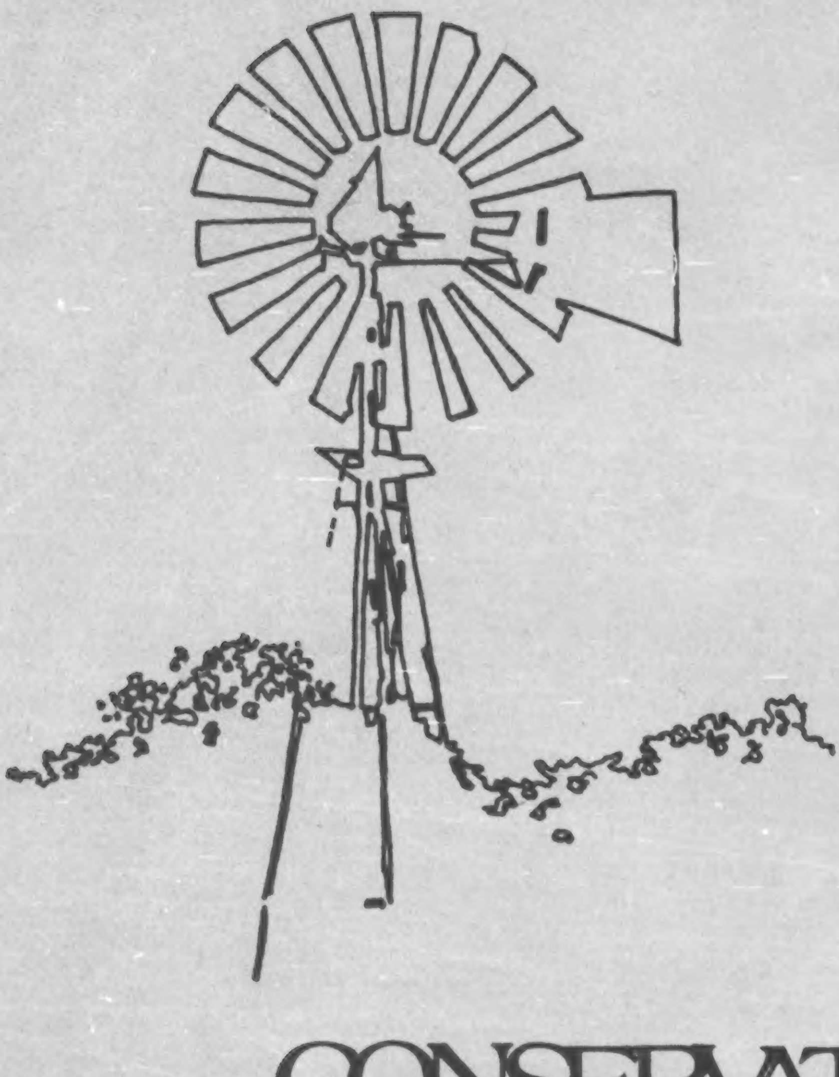
*Oil and gas investment depends greatly on the pricing and policy strategies that are adopted and could range from about $160 to $315 billion.

*Coal investment could increase to $18 billion or only 3 percent of the total, but representing a 200 percent increase from the 1965-1974 total of $6 billion.

*Investments to increase energy efficiency could also be significant, perhaps an additional $250 billion through 1985.

-- Conservation investments are difficult to separate from non-energy investments and will be spread throughout the economy.

*Note
The section entitled "National Energy Use" has been developed from selected materials of a report entitled, "1976 Executive Summary-National Energy Outlook" published by the Federal Energy Administration. Permission to reprint this information has been granted.



CONSERVATION

CONSERVATION OF ENERGY IN THE UNITED STATES

Components of U.S. Energy Consumption

In 1974 a total of 73.1 quadrillion (10^{15}) Btu's were consumed in the U.S.[1] This was, by the way, 2.2% less than the 1973 consumption of 74.7 quads, and thereby resulted in the first year-to-year decrease in 20 years.

The 1974 consumption was distributed among the major sectors as shown in Table A.

TABLE A

Sectoral Energy Consumption in 1974[2]

	Quads (10^{15} Btu)	Percent
Residential and Commercial	17.5	23.9
Industry	23.9	32.7
Transportation	18.3	25.0
Electric Power[3]	13.3	18.2
Miscellaneous	0.2	0.3
Total[4]	73.1	100.

In reading Table B it is important to realize that each category - U.S. energy consumption 1968, Changes in U.S. energy consumption 1960-1968, Average annual percentage rate of change 1960-1968 - mathematically refers to U.S. energy consumption and not to one another.

TABLE B

MAJOR COMPONENTS OF U.S. ENERGY CONSUMPTION[5]

	Percent distribution of:		
	U.S. energy consumption, 1968	Changes in U.S. energy consumption, 1960-1968	Average annual percentage rate of change, 1960-1968
Transportation	24.8%	23.8%	4.2%
Space heating	17.9[a]	16.6	4.0
Process steam[b]	16.7	14.2	3.6
Direct heat[b]	11.4	7.9	2.8
Electric drive[b]	7.9	9.3	5.3
Feedstocks and raw materials[b]	5.5	6.2	5.1
Water heating	3.9	3.9	4.3
Air conditioning	2.5	4.7	10.1
Refrigeration	2.2	2.6	5.3
Cooking	1.3	0.7	2.2
Electrolytic processes[b]	1.2	1.2	4.7
All above	95.6	91.4	4.1
All other	4.4[c]	8.6	10.9
Total	100.0%	100.0%	4.3%

[a] Comprised of: residential space heating = 11 percent; commercial space heating = 6.9 percent.

[b] These items refer almost exclusively to industrial usage.

[c] Of which residential and commercial lighting = 1.5 percent.

Improved Efficiency and the Second Law

The data in Table B leads to some observations regarding opportunities for energy conservation. First, the energy used for transportation, 25% of total consumption, can be reduced by a number of obvious measures, perhaps the most important of which is to improve the fuel efficiency of automobiles. There is no technical obstacle to achieving in the U.S. an average reduction of at least 50% in fuel consumed per vehicle-mile; Western Europe and Japan, by using smaller and lighter vehicles, approach this already. This goal can be achieved, incidentally, without sacrifice of emission control objectives, by selecting appropriate technologies.[6]

Second, 24% of total consumption is applied to space heating, water heating, and air conditioning. (The percentage in 1975 was probably even higher, due to rapid growth in the use of air conditioning and electrical resistance heating.) It is technically feasible to supply the same amount of usable energy for these purposes with the expenditure of less than one-quarter of the quantity of energy resources now being used. This could be done with the so-called Annual Cycle Energy System (ACES), which uses a heat pump and an insulated tank or reservoir containing a mixture of ice and water to provide hot or chilled water as needed. In northern latitudes the system might include a solar collector of modest proportions. Substantial gains in efficiency are also possible (with or without ACES) with improved insulation of buildings.[7]

Third, 28% of total consumption is used for process steam and direct heat in industry. Most of this steam and heat is at rather modest temperatures (less than 250 degrees C) compared with combustion temperatures. It is technically feasible to supply this heat with a much lower expenditure of net energy by either (1) generating by-product electricity as the temperature of the combustion gases released from the burning of fuel is lowered; or (2) obtaining the heat by withdrawing it from the environment with heat pumps designed for the purpose.

In the first of the above examples, efficiency is improved primarily by increasing the ratio of useful payload to gross vehicle weight. The second and third examples are based on a quite different method, that of minimizing the flow of heat from a high temperature to a low temperature with little or no useful work performed in the process. The principle involved is to increase efficiency as defined by the "Second Law of Thermodynamics."

The Second Law can be stated in many different ways, one of which is the following: heat will not flow, of its own accord, from a low temperature to a high temperature. From this simple and intuitive statement a number of important conclusions can be derived. Among them is that entropy, which is a measure of the lack of differentiation, is always increasing in a closed system. The system will, as time passes, become more homogeneous; differences in temperature and composition will disappear. Since life cannot exist without this differentiation, and since the universe can be regarded as a closed system, this leads to the prediction of the eventual "heat death" of the universe. Note that "heat death" does not imply death by high temperature; it refers to death arising from everything being at the same temperature, and of the same composition, so that no energy is available to sustain life.

This dismal conclusion, to be sure, will not be reached overnight. In our solar system we can expect the sun to provide us with light and heat (available energy) for hundreds of millions of years before it runs down.

Until recent centuries life on earth existed using only the "current income" of the sun. This has now been supplemented by use of the earth's "capital inventory" of fossil and nuclear fuels. The drawing down of capital stocks has driven a great expansion in use of energy. At current rates of consumption the only reserves of capital stocks which would last for more than a few centuries are uranium-238 and thorium (used in breeder reactors), deuterium (used in thermonuclear fusion reactors), and the earth's stored heat.

Let us note that the Second Law establishes the maximum theoretical efficiency by which heat can be converted to useful work. Most of the United State's energy is consumed in processes that are very inefficient (most no more than 10% efficient) when measured by this standard. Technologies are available to achieve much higher efficiencies but they have not been widely used. To date, however, historically low energy costs have inhibited the development and use of more technologically advanced and expensive solutions which improve 2nd law efficiencies.

There are enormous opportunities for energy conservation across practically the entire spectrum of energy use. Those who concentrate on only one sector, such as transportation, are likely to overlook equally important opportunities in other sectors.

Energy Consumption Trends

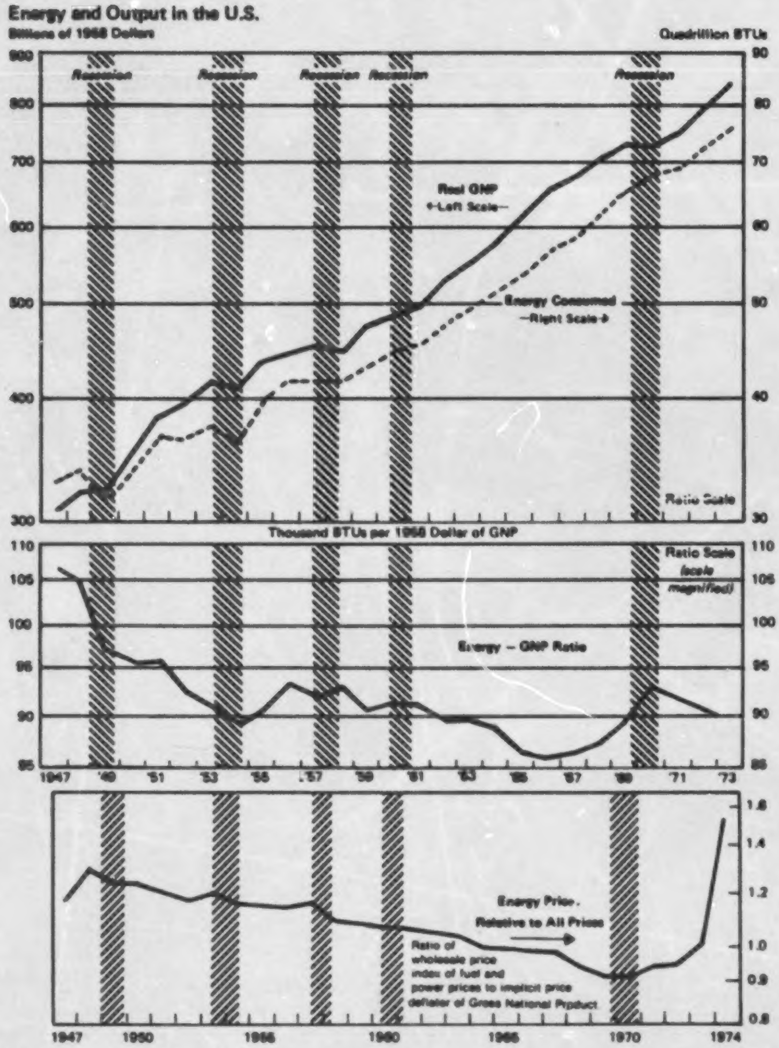
Energy consumption in the U.S. has increased rather steadily, though the rate of increase has been less, on average, than the rate of increase in real Gross National Product (GNP). The ratio of energy consumption to GNP has thus decreased on average, although in some years, for example the late 1960's, the reverse has occurred. The trends since 1947 are shown in Figure A taken from the FAS Public Interest Report. Note that energy prices relative to all prices decreased during almost all of this period, but that an unprecedented increase in energy prices has occurred beginning in 1973.[8]

One significant impact of this radical change in energy prices is that economic pressures will tend to encourage those alternatives for which the ratio of energy input to GNP output is relatively low. Those alternatives for which the ratio is high will tend to be priced out of the market. This will not happen overnight, since it takes many years for shifts in capital investment to be made. But it is to be expected that, on average, the ratio of energy to GNP will decrease at an even faster rate in response to present and prospective higher energy prices.

How much faster is a matter of much uncertainty and debate. If real GNP rose at an annual rate of 3.5%, then a 2% decline in the ratio would lead to a 1.4% per year increase in energy consumption. This particular rate of growth may or may not be optimum. Lower, even negative, energy growth rates can be achieved while sustaining growth in GNP, by implementing energy conservation technologies such as the ones discussed.

In this and other discussions of energy and GNP it should be noted that GNP is not an accurate measure of public welfare. GNP is no more or less than a measure of the money spent on final goods and services. It makes no difference, as far as GNP is concerned, whether the expenditure is voluntary or forced, or whether its marginal benefit exceeds its marginal social cost. For example, strategies which lower highway injuries or diseases produced by air pollutants will, to a first approximation, depress GNP because of reduced expenditures for medical care. It is to be expected that the savings will be used in other ways of more benefit to society than is injury or disease, but these alternatives would not necessarily produce an equivalent increase in GNP. More generally, it is not difficult to postulate patterns of life more satisfactory with respect to health, mental well-being, personal fulfillment, physical security, education, and most other measures of welfare (with the exception of rate of consumption of material goods) with no increase, and even a decrease, in per capita GNP.

FIGURE A



(from FAS Public Interest Report, October 1975)

Factors in Energy Use

Many factors no doubt affect the use of energy in the U.S. Let us consider the most important of these.

First there are the economic factors, perhaps most important of which is the price of energy in relation to the prices of other factors of production and to the general price level. If using more energy appears to be less expensive than investing in more efficient alternative systems and products, most decisions will favor using the energy. A corollary observation is that preferential subsidies of "intangible drilling costs," can be expected to lead to higher energy consumption, because energy prices will be lower than if such treatment had not been given. Similarly, when environmental and social costs, such as the damage to health and property from black lung disease, air pollution, or acid rain are not assessed on the polluter and included in the price of the product, more energy will be consumed than would otherwise be the case.

Another important economic consideration is family income. While direct energy demand (that used for residential heating, lighting, etc., and fuel for the automobile) levels off as family income rises, indirect energy demand (that embodied in goods and services) shows a linear dependence on income.[10] A strategy to increase family incomes will, therefore, work against a strategy of energy conservation, although both goals could be served simultaneously if policy elements were implemented to divert increased income into goods and services which are not energy intensive.

The use of energy is also affected by financial factors. Money may not be forthcoming to finance even economically justified alternatives. The financing of buildings is a case in point. Consider the case of two proposed buildings serving identical functions. One is conventional in design and in energy consumption. The second is designed to reduce energy consumption by means of improved insulation, an annual cycle energy system, and/or solar collectors. The initial cost of the second building is somewhat higher than the first, but the difference is more than made up with savings in operating costs. In a rational world one would expect financial institutions to be willing, even eager, to finance a higher percentage of the cost of the more expensive building, since the lower operating costs give greater assurance that the payments of principal and interest can be met.

Finally, social patterns and expectations are important, although the extent to which they are independent rather than dependent variables is not clear.

ENERGY SUPPLY IN THE U.S.

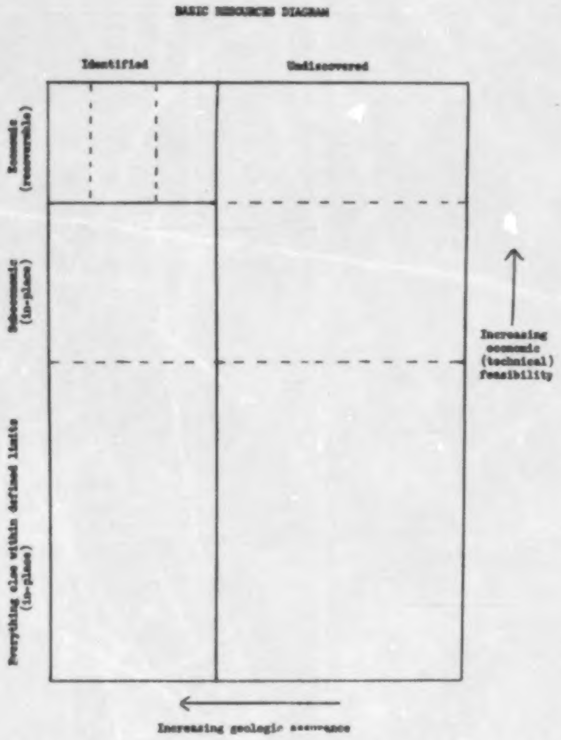
If abundant resources of low-cost energy were available, and if the environmental and social costs of using them were low, then there would be little motivation for energy conservation. In fact, resources are limited and/or expensive in terms of economic, environmental, and social costs. An examination of present and prospective energy resources will demonstrate the point. Only a brief summary of the most important energy supply issues is possible within the scope of this paper.

Oil and Gas

A simple way to depict the amount of a resource in terms of the degree of knowledge concerning its existence and the estimated economic cost of making it available is shown in Figure B. As one proceeds from left to right in the resources diagram, one moves from resources that have been clearly mapped, to others that are inferred on the basis of known geology, to others that are more purely speculative and perhaps based simply on an estimate of probabilities. As one proceeds from top to bottom, one moves from resources that are economically recoverable to others that are sub-economic (based on the economics of the industry at the time of the evaluation), to others which will probably never be economic to recover.

About 75% of the U.S. demand for energy is now being met with oil and natural gas, with 42% of the oil being imported. The status and prospects for domestic supplies of oil and gas are shown in Figure C. These estimates include Outer Continental Shelf (OCS) and Alaskan resources. They do not include oil from shale, or synthetic oil or gas from coal. The data is from Circular 725 of the U.S. Geological Survey, and has been further categorized by John J. Schanz.

FIGURE B


BASIC RESOURCES DIAGRAM
Identified
Undiscovered
Economic (recoverable)
Subeconomic (in-place)
Everything else within defined limits (in-place)
Increasing economic (technical) feasibility
Increasing geologic assurance

John J. Schanz, Jr.
Resources for the Future, Inc.

The numbers in the chart should be compared with present U.S. consumption of oil (about 6 million barrels per day) and gas (about 21 trillion cubic feet per year). If the perhaps optimistic estimate is made that about half of the subeconomic resource is now or will become economic, and that mean values of the undiscovered resource will indeed be found, domestic recoverable oil resources would total about 300 billion barrels, or 50 years at the current rate of oil consumption. The corresponding figure for gas is about 1100 trillion cubic feet, which is also about 50 years supply at the current rate of consumption. This does not mean that the resource would be depleted at a constant rate until exhausted; in practice, exploitation follows a bell-shaped curve with a decline beginning many years earlier. Indeed, domestic production of oil and gas did peak a few years ago, although it is possible that the current decline may be temporarily reversed under the influence of the economic stimulus of higher market prices. But the long term trend is clearly down, and even if there is no increase in total consumption of energy in the U.S., substitutes for domestic oil and gas will be needed.

One such substitute is imported oil and gas. Non-U.S. resources of oil, largely concentrated in the Persian Gulf, substantially exceed U.S. resources. The costs of relying on these supplies includes the economic disruption incident to manipulation of the OPEC price and, probably more important, the subordination of U.S. foreign policy to that of a few oil-rich Arab states. The memory of the capitulation of most Western European countries to Arab political demands during the Yom Kippur War in 1973 is still fresh in our minds.

FIGURE C

U. S. CRUDE OIL RESOURCES (10^9 BBLS.)

	Identified			Undiscovered
Economic 32%	34	5	23	50-127
Subeconomic 28%	147			44-111
Remainder in-place 40%	810			62-159

Cumulative production - 106
Unproduced resource base - 575-816
Original resource base - 681-922

U. S. NATURAL GAS RESOURCES (10^{12} CU.FT.)

	Identified		Undiscovered
Economic 80%	237	202	322-655
Subeconomic 10%	115		40-82
Remainder in-place 10%	115		40-82

Cumulative production - 481
Unproduced resource base - 1,071-1,488
Original resource base - 1,552-1,969

John J. Schanz, Jr.
Resources for the Future, Inc.

Source: USGS Cir. 725

The exploitation of oil and gas resources involves additional social and environmental costs, such as from oil spills, adverse impact on fragile and productive coastal zones, and encroachment on wild and scenic areas of unique value to this and future generations. These should also be weighed in an assessment of the desired extent and rate of exploitation of oil and gas resources.

Coal

About 18% of U.S. demand for energy is supplied by coal. The percentage has been in decline for 30 years as more convenient, cleaner, and, until recently, cheaper oil and gas displaced coal from the market.

A classification of domestic coal resources comparable to that described for oil and gas is not available, because no study has been made to estimate the fractions of the resource that are economic and sub-economic. There is one recent estimate which would correspond to the total of identified and undiscovered economic and sub-economic categories. It is 3 trillion tons. If one speculates that perhaps 20% of this may be economically recoverable (and this is no more than a guess), then at the current production rate of 600 million tons per year a 1000 year supply exists. If coal were to substitute for oil and gas, and supply a total of 93% of U.S. demand for energy, this amount of coal would last for about 200 years. If U.S. demand for energy continued to increase at historic rates (3.4% per year) the coal would last for no more than about 60 years. The figure would be even lower if the switch to coal resulted in a decrease in net energy available for each unit of energy consumed.

These estimates are at best very rough approximations, but they make the point that coal, though in more plentiful supply than oil and gas, is no substitute for energy conservation, nor is it a really long-term source of energy.

Hydro

A small and diminishing fraction of U.S. energy demand is supplied by means of energy generated by falling water. The best hydropower sites have already been exploited. Many of those that remain are in areas of unique scenic and sociological importance, such as in the Grand Canyon of the Colorado River and Hell's Canyon on the Snake River. Consequently, the potential of hydro to further contribute to U.S. energy supplies is low, and even a modest increase would be accompanied by high environmental costs.

Nuclear

The fraction of U.S. energy demand that is supplied by nuclear energy is also low, about 3%, but it has been increasing rapidly as new nuclear powerplants have been brought into operation.

A comprehensive discussion of the benefits and risks of nuclear power is beyond the scope of this paper. Only the most important points will be summarized.

First, if only the uranium-235 is used, as is essentially the case in conventional nuclear reactors, then high and medium-grade nuclear fuel resources will last for only a few decades. The use of low-grade resources, such as uranium found in low concentrations in the Tennessee shales, would appreciably extend this period. This would involve appreciable economic and especially environmental costs associated with the mining and processing of much greater amounts of ore; the mining operation would be comparable to that needed to obtain an equivalent amount of energy from strip-mined coal. The long-term use of nuclear fission power depends on the successful development and introduction of breeder reactors which will make use of the much more abundant uranium-238 (and possibly thorium as well). This would increase fission fuel resources more than a hundred-fold, putting them in the category of resources expected to last for a long time, that is for at least many thousands of years.

In normal operation the environmental and social costs associated with nuclear power are almost certainly much lower than those associated with the use of coal. The point of most severe disagreement between proponents and opponents of nuclear power is on the question of the risks and consequences of abnormal occurrences such as reactor accidents, sabotage, diversion of fissionable material for terrorist purposes, and accidental release of radioactive waste products to the environment. Opponents say that the risks are unacceptable; proponents cite studies that conclude that the risks are much lower than other involuntary risks assumed by society, and if desired can be made even lower. Opponents phrase the issue in moral and philosophical terms, saying that the fact that nuclear risks, whatever their magnitude, can affect future generations makes them qualitatively different than the risks of alternative resources. As previously noted in connection with fossil fuels and the risk and consequences of climatic change, this argument is at the least open to question.

With respect to economic costs, nuclear-generated electricity is at least competitive with electricity from coal, with the higher capital costs of nuclear compensated by lower fuel costs. A utility company, on the other hand, may well select a less economic higher fuel cost alternative if it has a lower capital cost, since costs associated with higher fuel prices can usually be automatically included in rates charged to customers.

The cost of power from new plants, both coal and nuclear, will be higher than the cost from most plants operating prior to 1973. So energy from coal and nuclear may be expensive compared with what has been experienced in recent decades.

Significant progress has been made in fusion research, but the technology is not yet at the point where a self-sustaining reaction, comparable to the fission experiment at the University of Chicago in 1942, has been demonstrated.

Radioactive materials will be produced in and adjacent to fusion reactors, but the quantities and types are such that risks associated with them will probably be somewhat lower than for fission. However, it is too early to do more than generalize on this.

The economic costs of fusion are likely to be fairly high because of required large capital investments. But, again compared to our other alternatives at that future time, it may be quite competitive.

Geothermal

Less than 0.1% of U.S. energy demand is now supplied from geothermal resources, and that from hot steam deposits. The potential is much greater, especially if hot water and hot, dry rock can be tapped. Technology to do so is under development at Los Alamos Scientific Laboratory and elsewhere. Some of the early results have been promising.

Problems associated with geothermal development include esthetic impact, noise, and possible release to the environment of brines, other toxic liquids and gases, and naturally occurring radioactive gases. It should be possible to reduce such impacts to an acceptable level by careful selection of areas to be exploited and by controls on the methods used.

The economic cost of geothermal energy from deposits of hot steam is relatively low, but these deposits are quite limited in extent. Exploiting hot dry rock is likely to be more expensive.

The typical geothermal operation "mines" the energy at a faster rate than it is replenished from natural radioactive decay and heat flow to that area. The lifetime of a particular operation is therefore limited, but the total amount of stored heat is so great that the geothermal resource must be classified as long-lived.

Oil from Shale

Oil shale is the most dilute energy resource ever seriously considered for commerical exploitation. A good deposit will yield about 30 gallons (0.7 barrels) per ton of ore. If as little as 10% of current U.S. oil consumption were supplied with oil from shale, it would be necessary to mine and process over 2 million tons per day of ore. This is more than the current mining rate for coal, which yields about five times the energy of that amount of oil.

The ore expands during processing, so that an added volume will have to be disposed of by filling in canyons or creating artificial hills. The processing requires large amounts of water in what is an arid region (western Colorado, northeastern Utah, and southwestern Wyoming). Air and water pollutants may also be a problem. The social impact of large-scale industrialization on a rural ranching and agricultural economy and way of life will be considerable. Oil from shale will be expensive in economic terms.

Oil and Gas from Coal

The issues involved in producing oil and gas from coal are similar to those associated with oil shale, although not to the same extreme. As noted previously, the large-scale use of coal as a substitute for oil and gas will shorten the useful life of domestic resources.

Solar

The potential of solar energy in its various forms--direct use of solar heat, photovoltaic conversion, heat engine conversion to electricity, biomass production and conversion, windpower, ocean thermal gradients, etc.--is most promising. Only a modest increase in the scale of the infant industry and the application of incremental cost pricing[11] to the alternatives (natural gas, electricity, and oil) is needed to make solar energy competitive in most low-temperature heating applications. The economics of other applications can be expected to improve under the stimulus of technological development and demonstration projects.

Social and environmental costs are probably low, but have not yet been studied with any thoroughness.

Solar energy is abundant; capturing only a small fraction of the amount falling on the U.S. would be sufficient to satisfy present demand for energy. It is not expected to be cheap, because of the capital costs associated with collection, storage, and conversion equipment.

Recapitulation of Energy Supply Alternatives

Our discussion of energy supply alternatives leads to the following conclusions:

- The energy resources upon which we now rely are relatively short-lived.
- Social and environmental costs associated with many of the energy supply alternatives are high.
- A few alternatives (solar, geothermal, the fission breeder, the fusion reaction) offer the possibility of long-term supply, but none of them, and none of the shorter-lived alternatives, is likely to be cheap.

In short, the era of cheap and abundant energy--if it ever existed (social and environmental costs were not counted!)--is no more.[12]

Regional Supply and Demand

It may be useful to temporarily depart from the national and international perspective heretofore taken to describe some regional issues.

The potential for regional conflict exists on a number of questions associated with energy supply. Coastal states, especially in areas not yet experiencing off-shore oil production, are justifiably concerned about adverse impact on the coastal zone. Many of the Rocky Mountain states are worried about the impact of massive mining and industrialization on a valued way of life and on the quality of the environment; they do not want to become "energy colonies" exploited by the rest of the nation. For this reason the policy of Montana is to allow the mining of coal in certain areas but to discourage the construction and operation of large energy conversion facilities within the state. The coal, rather than electricity or synthetic oil or gas, is exported, and the burdens and benefits of conversion are assumed by those closer to where the energy is used.

The South-Central States, major producers of natural gas, resent a regulatory structure which results in gas sold within their states priced at $2.00 per million Btu and that sold for use outside at $0.50 per million Btu. The New England states are particularly sensitive to increases in the price of imported oil and petroleum products. This sensitivity led them to oppose the President's energy plan of January 1975 because it contained a $2 per barrel fee on imported oil, though other elements of the plan, most notably decontrol of prices of old (domestic) oil, would put New England on a much more equal footing with other states with respect to energy prices.

On the demand side, there are major differences in regional per capita energy consumption, as shown in Table C.[13] It is hard to draw conclusions from this data without a much more detailed analysis, such as of the energy embodied in goods which are produced in one region and used in another. This may be largely responsible for the very high West South Central per capita industrial consumption. Differences in residential and commercial consumption are at least in party due to the climate.

TABLE C

SECTORAL VARIATION IN NET ENERGY CONSUMPTION--1972

	Per Capita Personal Income	Total BTU/Capita (10^6)	Residential & Commercial BTU/Capita (10^6)	Industrial BTU/Capita (10^6)	Transportation BTU/Capita (10^6)
National	$4,492	346	87.3	110.7	86.8
New England	4,754	253	113.3	29.1	67.0
Mid Atlantic	5,125	273	94.8	61.6	68.0
East North Central	4,741	346	105.7	110.1	74.6
West North Central	4,280	328	103.5	68.6	97.6
South Atlantic	4,186	278	63.8	65.5	84.2
East South Central	3,482	357	68.3	112.9	90.7
West South Central	3,819	560	72.1	289.7	113.4
Mountain	4,163	399	96.6	104.5	110.4
Pacific	4,881	287	70.5	60.9	92.7

The limited available data does not support the hypothesis that one particular region represents either the cause of the problem or its solution. Only comprehensive national strategies dealing with both energy supply and demand are likely to yield satisfactory outcomes. With regard to conservation of energy, there is no doubt that enormous opportunities exist in every region.

Why Conserve Energy?

The answer to the question: Why conserve energy? is apparent from the foregoing discussion.

First, conservation is economically justified; lower cost resources can be used to achieve the same ends.

Second, conservation expands our range of choices. It permits us to select those supply technologies that are most acceptable, and reject those that are relatively objectionable. Without conservation it might well be necessary to expand the use of all possible supply technologies, even those with high environmental and social costs, in order to meet the demand for energy.

Third, conservation will reduce U.S. dependence on unreliable and costly foreign sources of supply and make it less likely that U.S. foreign policy will have to be subordinated to that of a few oil-rich Arab states.

Fourth, conservation will free scarce energy resources for use in developing countries where the value of an incremental supply may be much greater than in the developed countries.

Lastly, conservation will perhaps result in a bit more of the easily accessible energy resources being left for the benefit of future generations. If we leave only the table scraps of low-grade resources we may be condemning them to a standard of living far below our own. Sophisticated technology, to be sure, may largely compensate, but it seems prudent to hedge our bets on that.

Conservation, in this context, is a long-term necessity, not a temporary expedient.

How Much Energy Should We Conserve?

Conservation of energy clearly makes sense. But up to what point? What are the criteria by which optimum conservation is obtained?

The resource economist will answer as follows: The optimum will be reached, leaving aside for the moment questions of imperfections in the market, when energy and alternative resources are priced at full incremental cost, including social and environmental costs. Correct price signals reflective of all costs will then be given, and the appropriate selection of resources made, in the sense that the most efficient combination of resources will be used to accomplish a given result. Also, the selection of society's desired results will be more reasonable, in terms of resources, under the influence of such prices. The inclusion of social and environmental costs would be accomplished through such mechanisms as regulatory standards and charges for emission of pollutants, the levels to be determined according to society's evaluation (generally done in a political decision-making Process) of those costs. Market imperfections would be dealt with directly, as with reform of guidelines for financing, mandatory labeling, "truth in advertising," government support of research and development, and, if necessary, the break-up of vertically and/or horizontally integrated companies or joint ventures when such structures restrict market access and discourage competition.

This approach is basically sound and, incidentally, is likely to lead to much more energy conservation than is now being practiced. If it has a major shortcoming it is with respect to decisions made by one generation that affect succeeding generations. For such decisions the use of a market rate of discount to relate present to deferred costs and benefits is inappropriate, since future generations are not participants in present markets. The question then becomes one of subjective values, with those who are sanguine about future prospects for technology, or perhaps indifferent to the fate of those who will follow them, favoring rapid exploitation to maximize current benefit. Those who are more questioning of the ability of technology to pull rabbits from the hat when needed, or who are more concerned about the need to preserve options and maintain continuity, will argue for a slowing of the rate of depletion of high-grade resources. An issue like this can only be resolved through a political decision-making process, despite its inadequacies, and despite the fact that those whose lives will be most affected (the unborn) have no vote.

If the decision is to slow the rate of depletion, a tax on the use of non-renewable energy resources would be an efficient and effective mechanism for so doing.

References and Footnotes

1. None of it was literally "consumed" in the sense that it vanished. The first law of thermodynamics, which holds that energy can be neither created nor destroyed (except insofar as mass is converted to energy or vise versa) still lives! In a technical sense what has occurred is that virtually all of the energy has been transformed from a condition in which it was able to perform useful work to a condition (in equilibrium with the external environment) in which it cannot be so used.

2. Data from Margaret J. Tifft, "Energy Consumption and Conservation in the United States," U.S. EPA, August 1975, p. 5.

3. Equals conversion losses or gross energy input minus electricity distributed. Electricity distributed is included in other sectors.

4. The actual total is slightly less than the sum of the individual sectors because of round-off error.

5. Stanford Research Institute, Report to the Office of Science and Technology, "Patterns of Energy Consumption in the United States," Washington, D.C., U.S. Government Printing Office, 1972.

6. National Academy of Sciences, Report of the Conference on Air Quality and Automobile Emissions, May 5, 1975, to the Committee on Environmental Decision Making (June 5, 1975).

7. H. C. Fischer, "The Annual Cycle Energy System," Oak Ridge National Laboratory.

8. FAS Public Interest Report, Washington, D.C., October 1975, p. 3.

9. ibid

10. Robert Herendeen, "Affluence and Energy Demand," Center for Advanced Computation Document #102, University of Illinois, December 1973.

11. Incremental cost pricing means that the price to all users is based on the cost of the incremental unit of capacity and energy, not on the cost of that unit averaged with all existing units. The costs should also include social and environmental costs.

12. If "abundant but not cheap" seems to be a contradiction, it is only necessary to reflect on the large amounts of scarce resources (land, labor, materials, etc.) that would be required to utilize certain energy resources that are abundant (solar energy, deuterium in water, etc.).

13. Margaret J. Tifft, op. cit., p. 8.

*Note

The section titled "Energy Conservation in the U.S." has been developed from selected materials of a report titled "Energy Conservation in the U.S.: Why? How much? By what means?" written by Laurence I. Moss. Permission to reprint this information has been granted by the Conservation Foundation - Washington, D.C.

TEXAS ENERGY

OIL AND NATURAL GAS - 76 FACTS

Oil is practically synonymous with Texas, yet oil and gas supplies are now declining in the state. This decline in the productive capacity of the nation's greatest oil producer should be viewed with alarm by all of the nation's consumers. This trend is even more significant to those within the state because of Texas' economic dependence upon the petroleum industry and other industries drawn to the state because of its energy supplies.

GENERAL

1. Lyne T. Barret drilled first Texas oil well near Nacogdoches in 1866; Texas became nation's No. 1 producing state in 1928.

2. Texas' first well was 106 feet deep.

3. Texas motorists are served by 17,000 service stations.

4. Texas consumes 7.5 billion gallons of gasoline a year, ranking second behind California.

5. Texas has 105,680 miles of natural gas pipelines: field and gathering, 12,341; transmission, 42,826; distribution, 50,513.

6. Texas has 65,472 miles of oil pipelines: 27,490 miles of trunk lines; 24,794 miles of gathering lines; 13,188 miles of product lines.

7. Petroleum accounts for nearly two-thirds of the tonnage handled in Texas ports.

OFFSHORE

8. Some 174 wells, including 162 wildcats, were drilled in the Gulf of Mexico off Texas in 1975. Total depth: 1,538,260 feet.

9. Of 162 wildcats drilled, 155 were dry holes. The 7 completions were gas wells.

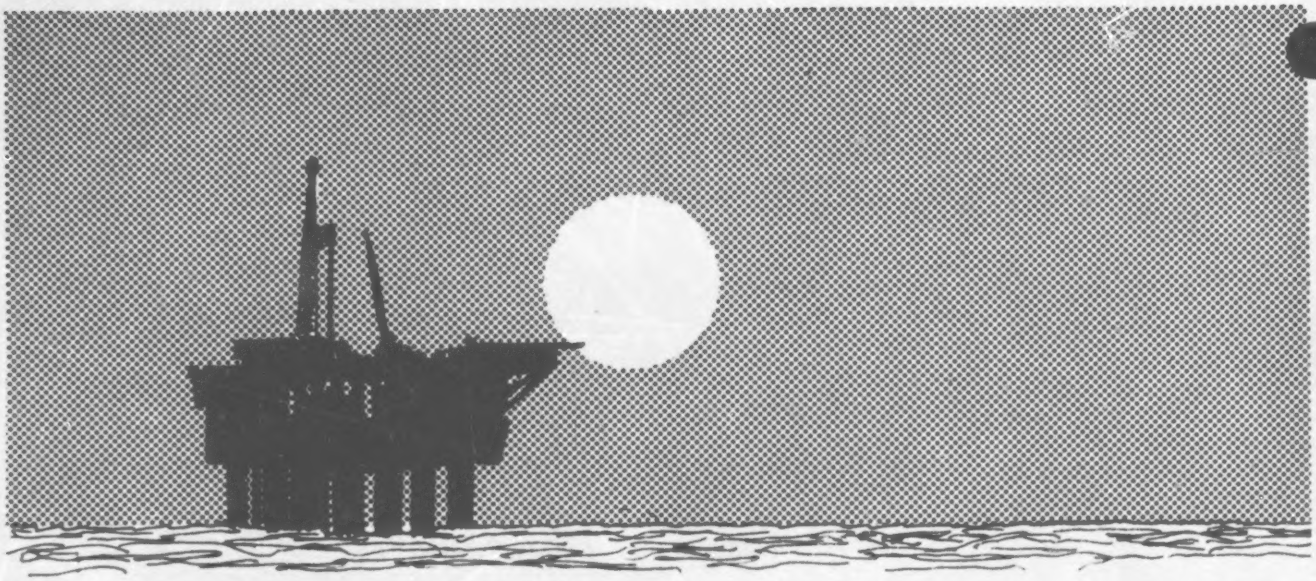
10. Of approximately $166 million spent in offshore Texas drilling ventures in 1975, some $155 million went into dry holes.

11. Cost of drilling a Texas offshore well averages $955,000 -- seven times the cost of the average onshore well.

12. Production from Texas offshore wells totaled 779,000 barrels during 1975: 426,000 from federal leases, 353,000 from state leases.

DRILLING

13. Texas oil men drilled 12,483 wells in 1975, including 397 test and service wells: 31.1% of U.S. drilling.



14. Texas drilling in 1975 totaled about 63 million feet of hole.

15. Nearly 26% of Texas wells drilled in 1975 were "wildcat" wells, which seek new fields. Only 28% of wildcats found oil or gas.

16. Wildcat wells were drilled in 221 of Texas' 254 counties during 1975.

17. Texas operators spent $1.8 billion drilling in 1975, $570 million lost in dry holes.

18. Average expenditure for drilling wells in Texas is $27 per foot.

19. Average depth of wells drilled in Texas in 1975: 5,409 feet.

20. Texas' deepest well, 28,500 feet, was completed in 1972 in Pecos County: a dry hole.

21. Of all Texas wells drilled in 1975 about 31% were dry.

22. An average of 637 rotary drilling rigs operated in Texas during 1975.

PRODUCTION

23. Texas has produced 40.7 billion barrels of oil, or 36.3% of U.S. total.

24. Texas produced 1.2 billion barrels of crude oil in 1975, 40% of U.S. total.

25. Texas produced 6.3% of world oil in 1975, 7.2% in 1970, 12% in 1960, 22% in 1950.

26. Oil or gas is produced in 211 Texas counties.

27. Texas has 5,031 oil producing firms.

28. Texas has 172,000 producing oil wells in 8,407 fields.

29. Of Texas wells, 89% must be pumped; only 11% flow from their own pressure.

30. Average Texas well yields 20 barrels per day.

31. Top 96 fields produce 69% of Texas oil.

32. Texas engineers estimate an additional two billion barrels could be recovered through "water flooding" and other special recovery methods.

33. State's deepest producer is Pecos County gas well at 23,040 feet.

34. Texas produced 37.5% of U.S. natural gas in 1975.

35. During 1975, 7.5 trillion cubic feet of Texas gas were marketed.

36. Of total Texas gas production, 80% (or four-fifths) came from 26,193 gas wells; about 20% (or one-fifth) from 159,663 oil wells (casinghead gas).

REFINING - PROCESSING

37. About 80% of Texas gas is processed for fuels like natural gasoline, propane, butane, etc.

38. Texas plants annually extract about 14.5 billion gallons of liquids from natural gas; 46.6% of the U.S. total.

39. Texas' 46 refineries processed 1.2 billion barrels of crude oil in 1975, equivalent of more than 99% of State crude production.

40. More than one out of every four gallons of U.S. major oil products is refined in Texas refineries.

41. Of Texas refining 87% is done on the Gulf Coast.

42. Texas refinery capacity is 3.9 million barrels of crude oil daily; 26.3% of U.S. total.

43. Texas carbon black production totals about 1.4 billion pounds per year, most of which is used in rubber manufacture.

44. There are 101 operating petrochemical plants in Texas.

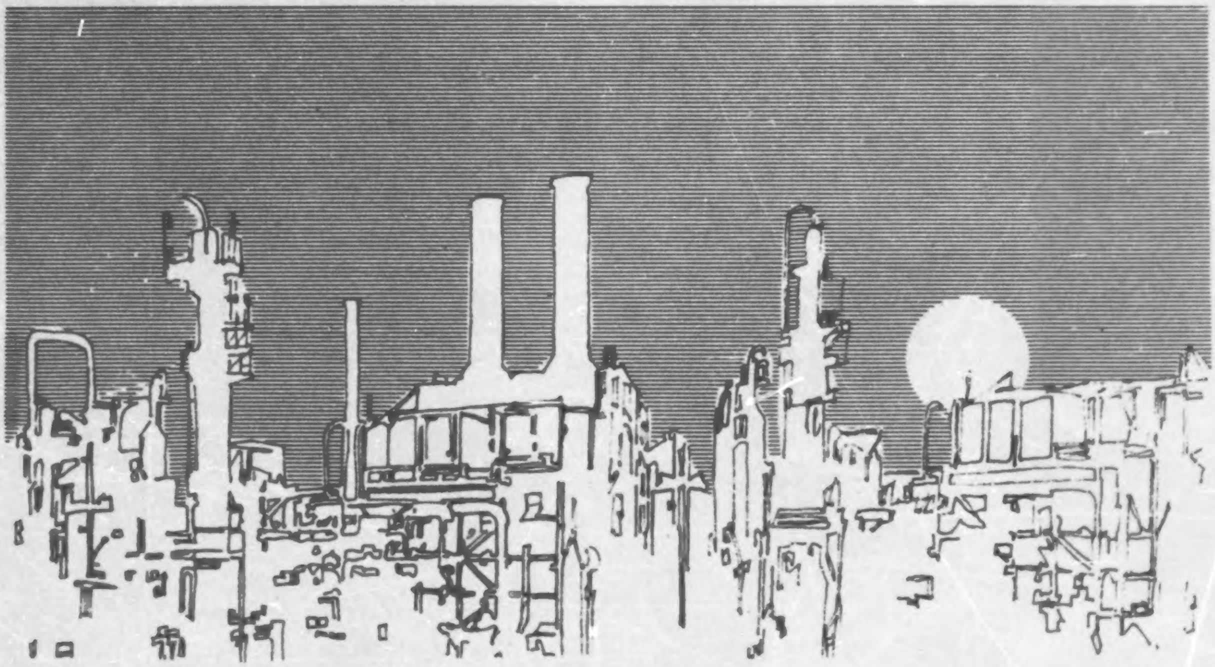
45. Texas is the nation's No. 1 producer of chemicals from oil and natural gas.

46. Refineries, petrochemical, natural gasoline or other processing plants are located in 138 Texas counties.

EMPLOYMENT

47. Texas petroleum industry employs some 263,000 persons (about one out of every 17 Texas workers) with wages of $3.2 billion annually.

48. Texas drilling and well service firms employed 62,800 workers in 1975 with wages of $776 million.



49. Workers in Texas petroleum production total 62,100, petroleum refining, 36,900.

50. Wages of Texas refinery workers average about $7.60 an hour, one of the highest rates in the State.

ECONOMICS

51. Texas has derived $114 billion from crude oil sales.

52. Texas oil and gas provide 26% of fuel energy produced in the U.S.

53. In 1975 the value of Texas crude oil natural gas and gas liquids was $15.2 billion; crude oil value: $9.5 billion.

54. Crude oil, natural gas and gas liquids accounted for 95% of the value of all mineral production in Texas during 1975.

55. Average price for crude oil in 1975 was $7.84 per barrel.

56. Texas has 32.7% of all U.S. oil reserves.

57. Texas has 12.7 billion barrels of oil reserves -- 10.1 billion in crude oil, 2.6 billion from natural gas liquids.

58. Texas royalty owners received $1.6 billion from oil and gas production in 1975.

59. Texas had 71 trillion cubic feet of natural gas reserves at end of 1975 (31.1% of U.S.).

60. Texas natural gas reserves have dropped 54.4 trillion cubic feet (43.4%) from peak year 1967; crude oil reserves have declined 5.2 billion barrels (34.2%)

from the 1951 all-time high.

61. Texas uses more natural gas than any other state (about 60% of the gas it produces).

62. Texas gas consumption: residential, 6.3%; commercial, 2.5%; industrial, 52.4%; electric utilities, 37.6%; other, 1.2%.

63. About 1.3 trillion cubic feet of natural gas are consumed annually in Texas for electric generation.

64. Wellhead value of Texas gas in 1975 was $3.7 billion; average price was 49.1 cents per 1,000 cubic feet.

65. Texas Permanent School Fund in 1975 received $96.4 million from petroleum industry for lease rentals, bonuses, royalty payments; total since 1932, $1.1 billion.

66. University of Texas Permanent Fund received $67.3 million in petroleum lease rentals, bonuses, and royalty payments in 1975; total since 1924, $737 million.

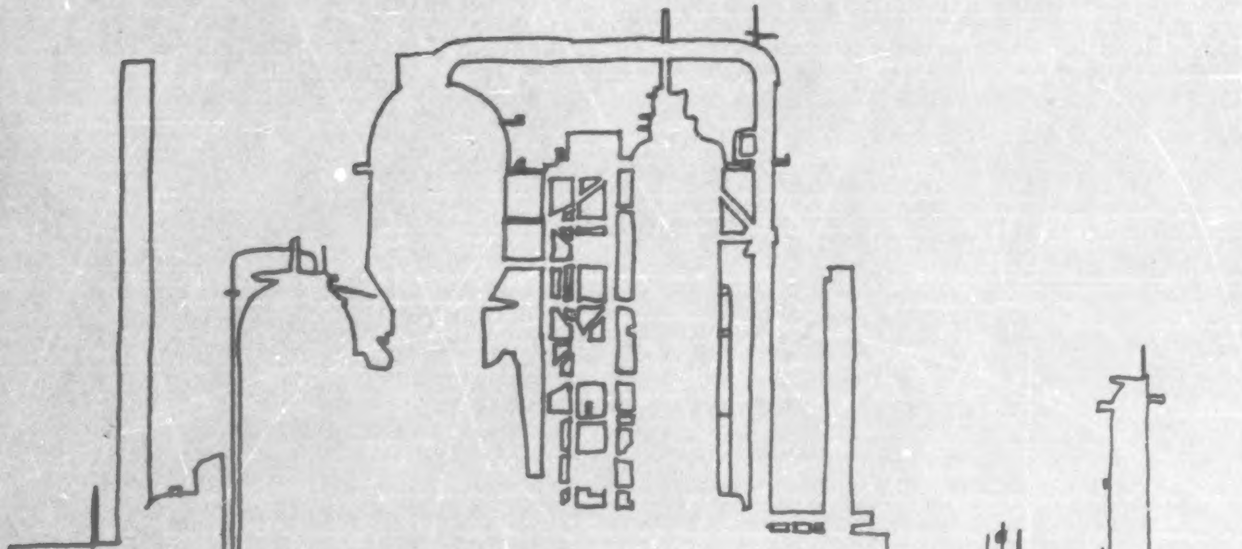
TAXATION

67. Texas petroleum industry taxes account for 21.2% of all State taxes.

68. Texas petroleum industry's 1975 tax payments to State government were $714 million.

69. Texas production tax rate on oil is 4.6% of value at well; 7.5% on natural gas.

70. Texas production taxes on oil raised $403 million in 1975; on gas, $260 million.



71. Texas oil and gas operators paid $2.2 million in regulatory taxes, and $2.0 million in well servicing taxes in 1975.

72. Texas petroleum industry pays 17% of State franchise tax; 29% of State property taxes.

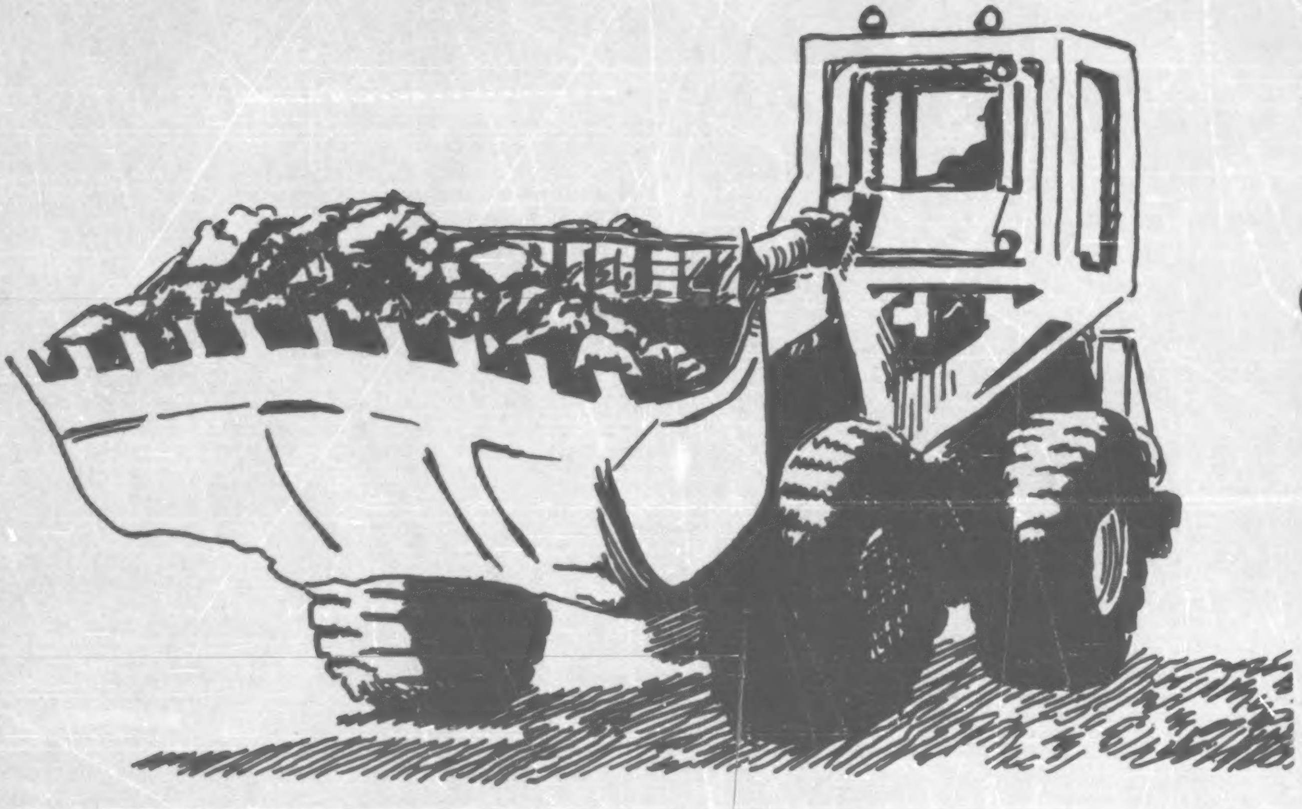
73. Texas oil and gas dollars pay for 59.7% of State cost of aid to dependent children, medical assistance, and teacher's retirement matching.

74. Oil and gas taxes provide 28.5% of the State funds spent for public education.

75. Texas gasoline tax at 5 cents per gallon yielded $395 million in 1975.

76. One-fourth of gasoline tax is used for public education, balance for roads.

*76 Facts supplied courtesy of Texas - Mid Continent Oil and Gas



COAL & LIGNITE

As the use of natural gas as a boiler fuel in electric utilities is phased out, the use of alternative fuels will be forced to increase. In the near term the major alternative to present fuels will be western coal and Texas lignite.

In 1975, Texas lignite represented approximately 9% of the fuel usage of the electric utility industry; no generation plants using western coal were in operation. Based on data from the Texas electric industry, it is projected that by 1985 approximately 23% of the state's electricity needs will be met by lignite and 20%

by coal. Depending on regulatory actions and availability of natural gas and fuel oil, the contribution of lignite and coal may be even more significant.

The purpose of this section is to review projected plans for utilization of western coal by electric generation plants to be located in Texas. The contracted cost of coal is not fixed but will increase in time in accordance with changes in various production, transportation, and economic factors.

Subsequent parts will review plans relative to Texas lignite and the factors which influence the decision to use Texas lignite or western coal.

The first coal-fired power plant in the state will be Southwestern Public Service Company's Harrington Plant. Located near Amarillo, Harrington Unit 1 is scheduled to begin operation in August of this year. The 360 MW facility will use coal from the Amax Coal Company mine at Belle Ayr, Wyoming. The coal will be transported by unit train to the plant by Burlington Northern, Inc. at a total cost of approximately $12.25 per ton. Harrington Units 2 and 3, which are to be the same size as Harrington Unit 1, are scheduled to begin operation in 1978 and 1980.

In addition to Harrington Plant, Southwestern Public Service also plans to build a second plant, known so far only as Plant X, which is currently unsited but will possibly be located in the area of Muleshoe. Plant X will consist of two 475 MW units which are scheduled to begin operation in 1982 and 1984.

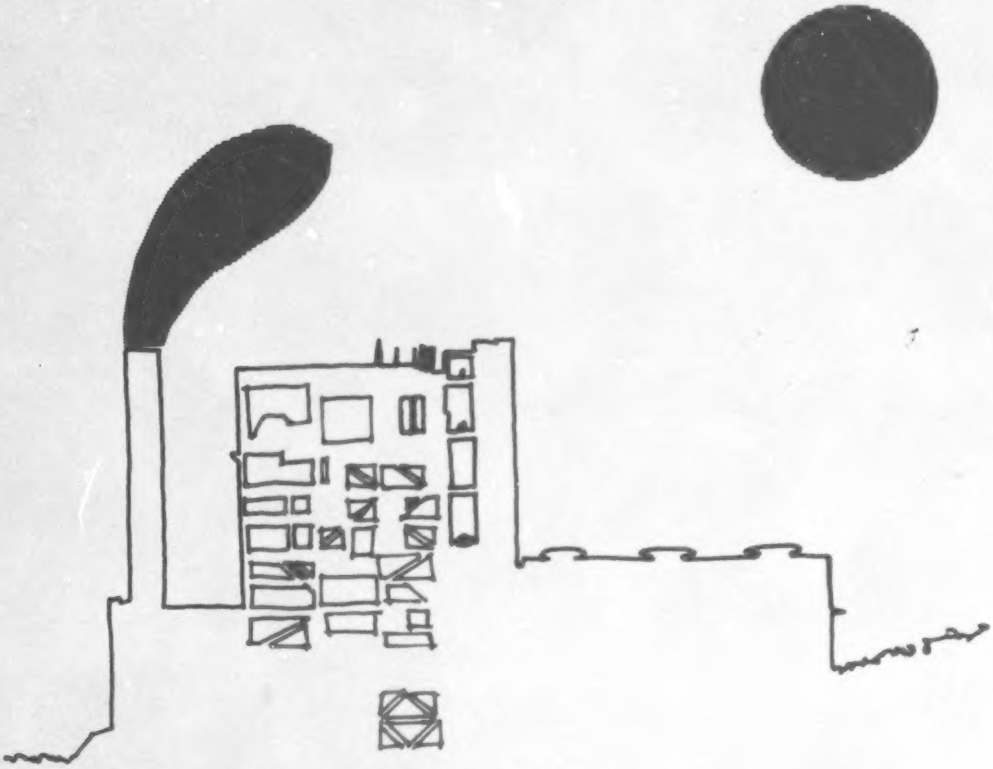
Southwestern Electric Power Company, which serves the northeast corner of the state, is in the process of building the first unit of a three-unit facility at Cason. Known as Welsh Plant, each unit is rated at 528 MW. The units are scheduled to begin operation in 1977, 1980, and 1982.

Each unit will require approximately two million tons of coal per year. This coal will move from Wyoming to Kansas City, Missouri on the Burlington Northern, and then into Texas on the Kansas City Southern Railroad -- a distance of 1,469 miles.

The City Public Service Board of San Antonio is planning to import three million tons of coal per year for J. T. Deely Plant beginning in 1977. The coal is coming from Wyoming over the Burlington Northern to Fort Worth, and then on the Southern Pacific to San Antonio.

Deely Plant will consist of two units rated at 447 MW each; both units are scheduled to begin operation in 1977. A third unit, rated at 375 MW, may use coal, but CPS is currently investigating the use of lignite. This unit is scheduled for start-up in 1983. Estimated cost of coal is $19 per ton.

Houston Lighting and Power Company plans to build four 750 MW units at the W.A. Parrish Plant in Richmond. These units, which are scheduled to enter commercial operation in 1978, 1979, 1981, and 1982, will use approximately 2.5 million tons of coal per year each. When the fourth unit is completed, Parrish Plant will be among the largest coal-fired power plants in the world.



The coal for the plant, which is scheduled to come from Wyoming, will probably be moved by the Burlington Northern. An additional 750 MW unit is currently scheduled for construction in 1985, but has not yet been sited.

The Lower Colorado River Authority and the City of Austin are jointly planning construction of two 550 MW units at Fayette Plant near LaGrange. The coal for Unit I, which will enter service in 1979, will come from Decker, Montana.

This two-million ton per year shipment will move on the Burlington Northern to Houston, and then on the Missouri-Kansas-Texas Railroad to the plant. Cost of the coal is estimated at $20 per ton. The fuel source for the second unit, scheduled for start-up in 1980, has not been selected.

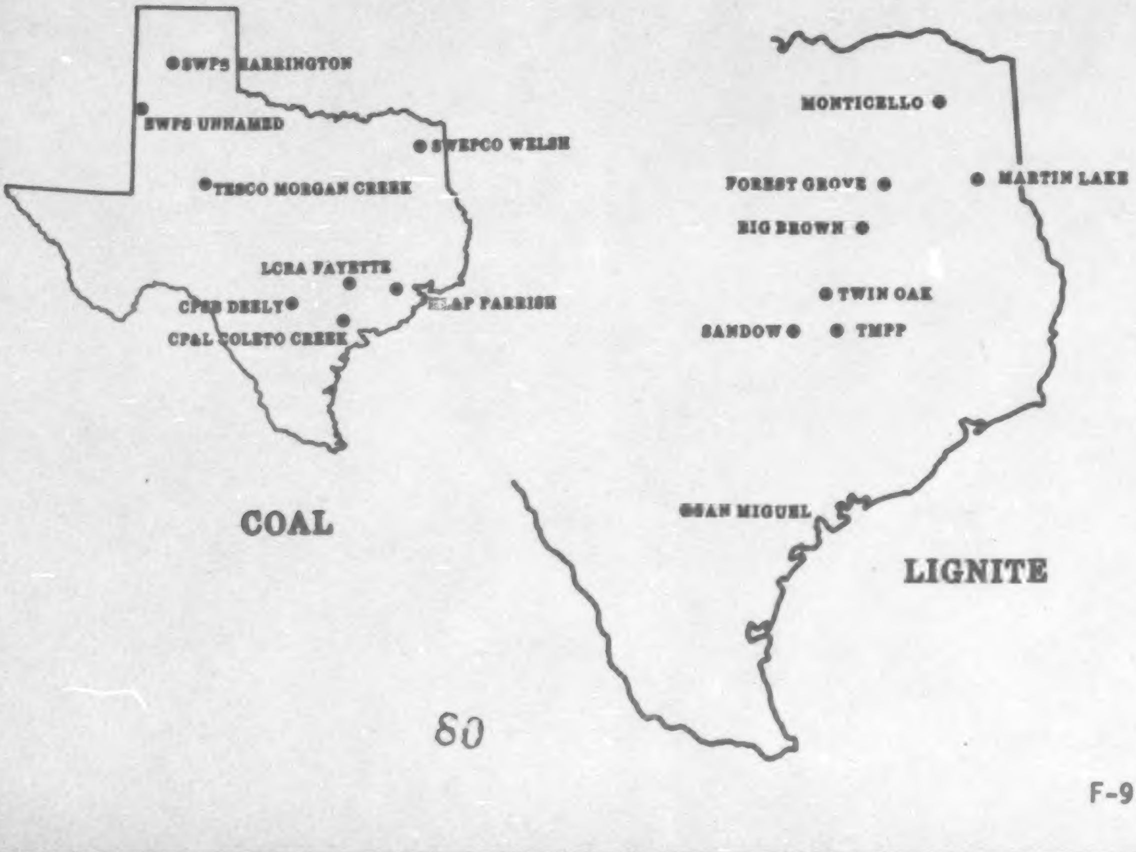
Central Power and Light is planning two 550 MW units for its Coleto Creek Plant near Fannin. These units are scheduled for start-up in 1979 and 1986. Each unit will use approximately two million tons of Wyoming coal per year.

The Texas Utilities system is composed of Texas Power and Light, Texas Electric Service Company, and Dallas Power and Light. The Texas Utilities System recently signed a letter of intent to purchase 500 million tons of coal in the San Juan Basin in New Mexico, with an option to purchase an additional 300 million tons. Dallas Power and Light is the state's largest user of lignite.

Although no definitive plans have been announced, it is believed that this coal will be used in the western portion of the Texas Utilities system. This usage would help balance the system's generation capacity, which is largely concentrated along the lignite belt of east Texas. Due to the relatively short transportation distance, total delivered cost to the Morgan Creek Plant near Big Spring would cost approximately $16 per ton.

West Texas Utilities does not have any definitive plans for coal utilization, but may use coal in two unsited 250 MW units which it plans to put into service in 1982 and 1985.

COAL & LIGNITE FIRED POWER PLANTS


SWPS HARRINGTON
SWPS UNNAMED
SWEPCO WELSH
TESCO MORGAN CREEK
LCRA FAYETTE
CPSB DEELY
HL&P PARRISH
CP&L COLETO CREEK
MONTICELLO
FOREST GROVE
MARTIN LAKE
BIG BROWN
TWIN OAK
SANDOW
TMPP
SAN MIGUEL

COAL

LIGNITE

This review covers only the coal use projected for the electric utility industry. A significant future demand for coal may also be exerted by the petrochemical industry. This demand, initially, would be for process heat use. The technical and economic feasibility of using coal to supply synthesis gas and hydrocarbons for feedstock use is also being studied.

Western coal use for electric power generation in Texas will grow from zero in 1975 to an estimated 30-35 million tons per year in 1985. If railroads use unit trains exclusively, the transportation of this coal would require by 1985 eight to ten unit trains of 100-ton cars each to enter the state every day. The total rolling stock requirement would be approximately 6,000 hopper cars and 240 locomotives.

The utilization of this amount of western coal as an alternative would save approximately 600 billion cubic feet of gas in the year 1985. This is the equivalent to 8% of Texas' 1975 production of natural gas and 45% of the natural gas used by the electric utility industry in 1975.

The first record of lignite occurrence in Texas is found on a map by L'Heriter published in Paris in 1819. Prior to the advent of oil and gas, lignite was a principle energy source in the state; annual production peaked at 1.4 million tons in 1914. With the emergence of oil and gas, lignite production declined to near zero by 1940.

In 1954, at a time of widespread natural gas use and availability, Alcoa opened a lignite surface mine near Rockdale to produce fuel for generating electricity to be used in aluminum processing. Sandow Plant, the name given to the generating facility, was the first major mine-mouth power plant in the state. It has a capacity of 360 megawatts, with sixty megawatts utilized by Texas Power and Light.

By the 1940's and 50's, the Texas Utilities System had recognized the future significance of lignite and had undertaken an extensive exploration and acquisition program. Their efforts resulted in significant holdings of higher quality lignite, primarily in the Wilcox formation.

The first lignite-fired power plant built exclusively by Texas Utilities was Big Brown, near Fairfield. Put into commercial operation in 1971, Big Brown consists of two 575 megawatt units. These units obtain lignite from a company-owned and operated surface mine near the plant. Big Brown, has served as a testing station to demonstrate both the feasibility of Texas lignite utilization for commercial electric power and the environmental impact of lignite mining and utilization. Although not all questions have been answered, the plant has on the whole operated in an exemplary fashion according to industry spokesmen.

A second lignite-fired plant has been put in service by Texas Utilities near Mt. Pleasant. Known as Monticello Plant, this plant, currently consists of two 575 megawatt units. A third unit, rated at 750 megawatts, is scheduled to enter commercial operation in early 1978. Two interesting factors about the plant are the use of an electrified unit train to deliver lignite to the plant (the third such application in the U.S.) and the use of bag filters to catch particulate discharge in parallel with the electrostatic precipitators (due to high electrical resistivity of the fly ash which has limited the effectiveness of the precipitators).

Martin Lake Plant, to be located near Henderson, will be the third and largest of Texas Utilities' planned lignite plants. Consisting of four 750 megawatt generating units and associated mining activities, Martin Lake will be among the largest mine-mouth operations in the country. These four units are scheduled for commercial operation in 1977, 1978, 1979, and 1981. Upon completion of Unit 4 the total annual usage of lignite will approach ten million tons per year. This is roughly equivalent to the state's current total production of lignite.

Two additional lignite plants are in the planning stage by Texas Utilities. Forest Grove Plant will consist of one 750 megawatt unit. Scheduled for start-up in 1981, Forest Grove will be located near Athens. Twin Oak Plant, to be located near Franklin, will consist of two 750 megawatt units. These units are scheduled for start-up in 1982 and 1983. Of the total capacity at Twin Oak, 350 megawatts will be owned by a large industrial customer.

An additional 1150 megawatts of capacity is scheduled for operation by Texas Utilities in 1985. The specific siting of these units has not been selected, but they will probably be located in the central portion of the Wilcox formation.

By 1985, 50 to 60 percent of the power production of Texas Utilities will be based on lignite. All of the lignite will be supplied by surface mining along the Wilcox formation.

Texas Utilities is also currently involved in evaluation of "in situ" gasification equipment leased from the Soviet Union. Should these efforts indicate the commercial feasibility of the technology in Texas, the vast deep basin lignite resources of the state may be recoverable. Utilization of this resource, estimated at 10 times the size of the near surface resource, could be by either conventional central station steam plants or mobile, skid-mounted, combustion turbines which could be moved from gasification site to gasification site as the resource beneath is depleted.

Texas Utilities is not alone in the use of lignite. Considerable interest is being shown in the planned San Miguel Plant. A joint project of the South Texas & Medina Electric Cooperatives' Pool and the Texas Municipal Power Pool, San Miguel is being built near Tilden to utilize lignite from the Jackson-Yegua Formation in South Texas. As opposed to the lignite used by Texas Utilities, which is commonly 10 percent ash, one percent or less sulfur, and 7000 to 7500 BTU/lb, the lignite for San Miguel Plant is approximately 40 percent ash, 2 percent sulfur, and 5500 BTU/lb.

If San Miguel Plant can be operated without excessive operational problems, the outlook for utilization of lower grades of Texas lignite will be greatly improved. San Miguel Plant is designed to consist of two 400-megawatt units scheduled for operation in 1979 and 1980.

Texas Municipal Power Pool also has another lignite project under consideration. As presently projected, this project will consist of three 400-megawatt units to be operated initially in 1982, 1983, and 1984. Although not yet definitely located, the plant will most likely be near Bryan. It will utilize lignite from the Yegua or Jackson Formations.

In addition to these activities by the electric utility industry, the petrochemical, primary metal, building products, and other industries also are interested in utilizing lignite. As many as ten different companies have been involved in lignite exploration and leasing programs during the past few years. Shell Oil is currently in the process of developing an environmental impact statement for its holdings in Milam County. This leasing activity has resulted in considerable speculation. Current leasings are running near $1.00/million BTU.

The future of Texas lignite indicates that considerable development will occur. Surface lignite utilization by the utility industry will approach 40 million tons per year by 1985. Allowing for use by other industries, total utilization may reach 55 million tons. This production would almost certainly place Texas in the top 10 coal producing states in the nation.

*Texas Energy Report - July, August - 1976

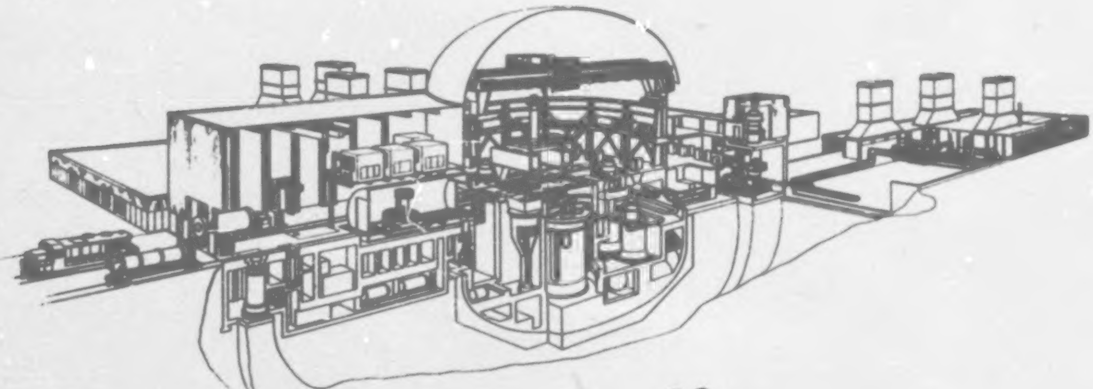
NUCLEAR ENERGY

Texas, though ranking third in domestic uranium reserves and present production, has been slow to develop nuclear energy for electric power generation because of previously abundant, low-cost natural gas. Of the approximately 60 nuclear-electric units operating in the U.S., none are located in Texas. However, by 1985 at least 4800 mwe, or about 8% of state generation capacity will be nuclear.

Meanwhile, by 1980 at least 10% of the nation's production of uranium may come from Texas, largely due to the impact of in situ leach uranium production techniques. By 1982, with successful Congressional passage of the Fuel Assurance Act, TRENCOR, a uranium enrichment venture proposed for Texas will begin operation. Our state, due to its natural, industrial and human resources, can in the future not only support development of nuclear fuel cycle facilities but also use to great economic advantage its nuclear-electric generation capability.

Nuclear energy, as with all our energy alternatives to oil and natural gas is not, individually, a panacea for our current and near-future energy dilemma. However, in the short term both nuclear and coal can offer the cheapest base load electricity available to Texas.

Both coal and nuclear power generation have disadvantages. Nuclear plants, for example, need up to ten years lead time from license application to operation. The South Texas Project is presently on-schedule for operation in October 1980, six years and five months from its initial application to the Nuclear Regulatory Commission. Pending before Congress is legislation to generally streamline the nuclear licensing time-frames.



Unlike some other areas of the nation, the move toward nuclear power has been greeted with only limited opposition in Texas. The construction permit hearings for the Comanche Peak, Allens Creek and South Texas Projects revealed no large-scale disapproval.

However, in certain areas of the state, especially those affiliated with recently high electrical-rate increases due to large cost-increases (up to 800%) in natural gas for power generation, a widespread discussion of energy issues has included those on nuclear power, centering largely on economics rather than safety.

Under the current interpretation of the Reorganization Act of 1974, the Atomic Energy Commission was abolished with the Nuclear Regulatory Commission assuming its regulatory functions under the Atomic Energy Act of 1954. The Energy Research and Development Administration apparently received no clear mandate to "promote" nuclear power when it assumed the nuclear research and development duties formerly also resting in the AEC. Indeed, as with no other energy source, the federal government controls most aspects of nuclear power. However, about half the states, including Texas, share certain nuclear regulatory responsibilities and, the NRC is now working with certain states to hold joint licensing hearings on site related matters.

URANIUM PRODUCTION

This year about 10% of the nation's electric power is being generated by the 60 nuclear plants now in operation. By 1985, the Atomic Energy Commission predicts nuclear energy will account for just under 40% of America's electricity supplies. By 2000 the nuclear share should be 70%.

Current nuclear plants, as well as those to be constructed during the next decade, are fueled by uranium -- a naturally occurring radioactive metal which makes up about two parts per million of the earth's crust.

As nuclear energy begins to assume its predicted role as a primary energy source, the exploration, production and refining of uranium will grow proportionately.

Texas is a major producer of uranium and is number three among 50 states in uranium reserves.

Nuclear Fuel Cycle - In order to understand the role Texas plays in the nuclear industry, a simplified explanation of the nuclear fuel cycle is in order.

Present day nuclear plants utilize uranium to create a fission reaction producing heat which in turn generates electricity through the usual steam - turbine cycle. Most steam - electric power plants use coal, fuel oil and (in Texas especially) natural gas. The energy potential of a pound of concentrated uranium ore is equivalent to 100,000 cubic feet of natural gas or 15,000 pounds of western coal.

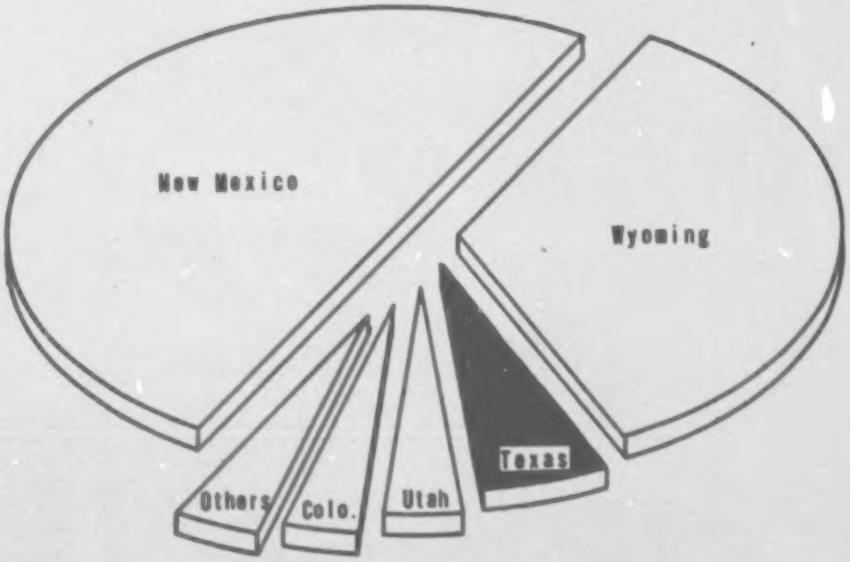
In nature, uranium is generally found in combination with other elements which, in turn, are scattered sparsely within an ore body. Present day nuclear plants can only utilize about seven-tenths of one percent of that uranium (U-235) directly. (The breeder reactor, which is under development but not expected to produce significant power before the late 1990's, will vastly increase uranium utilization.)

The complex series of steps leading to the fabrication of the nuclear fuel used in reactors begins with ore exploration. Early exploration for uranium used only Geiger counters, and scintillation counters which located radioactive materials near the surface. Today deeper ore bodies are discovered through drilling. Once an economically extractable deposit is discovered the ore is removed by open pit mining. The ore is then trucked to a nearby mill where concentrated uranium oxide, U_3O_8 (commonly called "yellow cake") is extracted from the ore. On the average, each ton of ore yields 2 to 3 pounds of yellow cake. From the mills the uranium oxide is shipped to facilities refined, converted and fabricated to a suitable form for use in nuclear plants.

In Texas the fuel cycle today ends with the milling phase. However, by 1980, two nuclear plants are expected to begin operation in Texas. By 1982 there may be a demonstration centrifuge enrichment plant in operation in Texas.

The remainder of this section will focus in somewhat greater detail upon the exploration, mining and milling of uranium in Texas.

Distribution of 1/1/73 Ore Reserves by State
$8.00 Reserves



Location of Uranium Deposits. In a 1969 monograph entitled "Uranium in Texas," Hoyt Eargle delineates five general areas of known uranium occurrence. These are: (1) several sites in the Panhandle along the Caprock Plains in Oldham, Briscoe and Garza counties; (2) in the Trans-Pecos region in Brewster county; (3) the Llano uplift of Central Texas; (4) along the Red River; and (5) a 300-mile stretch of the Gulf Coastal Plain from Starr County in the southwest to Fayette county in the Northeast.

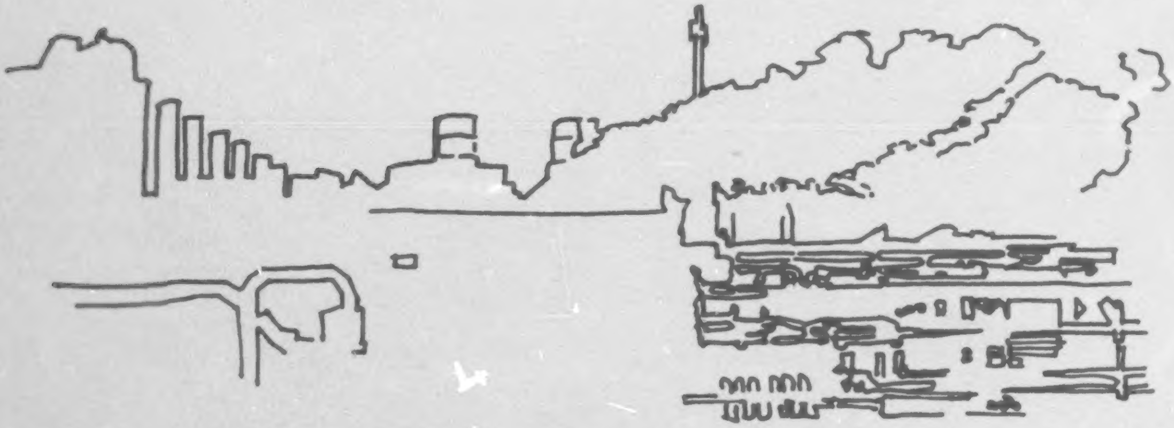
With the exception of some early mining in the High Plains and Big Bend area, all of the commercial activity has occurred in the Coastal Plain centering around an area about 50 miles southeast of San Antonio in Karnes and Live Oak counties. Between five and six percent of the nation's known uranium reserves are located in this area known as the South Texas Uranium District.

Exploration and Mining. The discovery of uranium in South Texas occurred in 1954 in connection with oil exploration. The principal deposits of near-surface ores were located 9-12 miles southwest of Falls City. Mining began in 1958 when the San Antonio Mining Company, a subsidiary of Climax Molybdenum, began open pit mining of three ore bodies in this area. Eargle writes that the pits ranged from 20 to 40 feet in depth and were more than 1,000 feet long. Following the San Antonio Mining Company operations, other mines began to open with larger and deeper pits. Eargle notes that one deposit has resulted in "a pit more than two miles long and as much as 130 feet deep."

Virtually all of the uranium mining in Texas has utilized open pits -- a form of surface mining which eliminates the need for underground mining with its health and safety problems. The nature of South Texas deposits (loose, unconsolidated, overburden) and the presence of hydrogen sulfide render tunnel mining as an impractical alternative.

The disadvantages of open pit mining in the past were primarily two-fold. The pits left scars on the landscape and like other forms of surface mining were detrimental to the environment. The older Texas uranium mines have only been partially reclaimed. The Surface Mining and Reclamation Act of 1975 as executed by the Texas Railroad Commission enforced environmentally acceptable mining of lignite and uranium followed by proper reclamation procedures.

The exploration for uranium in South Texas has continued at a rapid pace and in 1975 accounted for 13% of the total exploration effort. Through the first six



months of 1976 drill rig activity is up 45% from 1975. One of the most hopeful technological breakthroughs is underway in the South Texas area. A production plant about 10 miles southwest of George West is extracting uranium using an in situ process. By injecting a chemical solution into the deep ore body, a slurry containing the uranium is forced up through a second well and recovered. The in-situ process offers the hope of increasing reserves as deeper and remote ore bodies become economically extractable.

Milling. The AEC's "The Nuclear Industry, 1973" publication lists 18 uranium mills in the nation with a combined capacity for processing 28,550 tons of ore per day. Three of the 18 mills with a total rated capacity of 3,750 tons are in Texas.

However, during 1973 two mills were closed. Both were owned by Susquehanna-Western Company and were located at Ray Point and Falls City. The Ray Point Mill was sold to Exxon and is considered to be on "standby." The Falls City Mill is older, less efficient and less likely to be reopened in the future. This mill has also been recently sold to Solution Engineering. The third mill, the newest and largest of the three is in Falls City and is owned by the Conoco and Pioneer Nuclear, Inc. It has a rated capacity of 1,750 tons of ore per day. By 1980 with the commercial expansion of the in situ uranium leach operation and the opening of at least two more surface mines, Texas production should exceed 5,000,000 pounds per year.

Future. There are several factors which will determine the continued viability of the Texas uranium industry. It is certain that the demand for uranium will increase--perhaps by six to eight fold before the year 2000. The growth in demand should result in higher prices for uranium. Because of past AEC pricing policies the uranium industry has undergone wide fluctuations in exploration and mining. In the last four or five years the price per pound of uranium oxide has risen from about $6.00 to current spot prices of about $47.00 per pound. Still cost of uranium is a relatively small portion of the total operating costs of a nuclear plant. It has been estimated that a doubling of U_3O_8 prices would boost the cost of electricity by about 10%. Therefore the price of uranium could easily climb without seriously affecting the competitiveness of nuclear power relative to oil and coal.

In addition to economic considerations, the industry will be affected by technological development. The current proved and potential domestic reserves of uranium are 3 million tons. Without the breeder reactor or significant reductions in the use of energy, the nation will need this 3 million tons between 1975 and 2020. Obviously new reserves or improvements in reactor efficiencies must be developed. Due to the expense of exploration and past insecurity of the uranium market, however, commercial suppliers probably will not "prove out" more than a 10 year forward reserve of uranium. For this reason many Texas electric utilities are developing their own or joint exploration programs to secure their own reserves.

Summary - With less than a thousand employees, the uranium business in Texas is far from having a major impact on the State's economy. However, as oil and gas resources of the state and nation continue to dwindle the uranium industry is sure to take on added importance. Higher prices may, in fact, open up other areas of the state for mining. Currently, only exploration, mining and milling is conducted in Texas. As nuclear plants come on line there is a possibility that other fuel processing activities will move into the state.

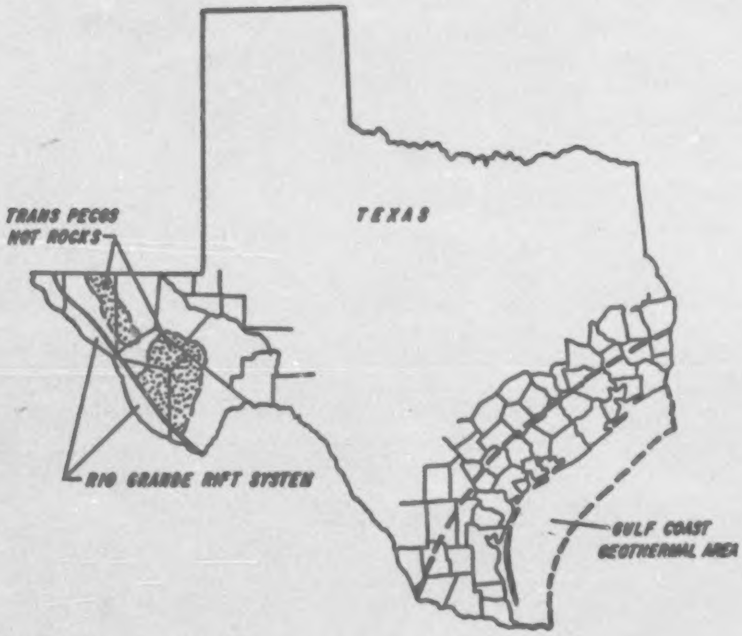
Texas Energy Report - Oct. 1974, revised July 1976.

GEOTHERMAL

Recent shortages of oil and gas have underlined our dependence on these depletable resources for the maintenance and growth of our present way of life.

We have suddenly experienced what some energy experts have been predicting for years -- that the available supply of oil and gas is rapidly being used and at present consumption rates will soon be exhausted. Even with a strong conservation program, an adequate long range supply will demand the commercialization of what have been called the exotic energy sources, solar, geothermal, tidal, wind, etc.

State, federal, and private funds are being channeled into the research and development of these resources. Several studies of the Governor's Energy Advisory Council have been devoted to assessing the potential of these sources in Texas and delineating production areas. Results show that Texas, a leader in oil and gas production, is also a potentially large producer of the exotic energy sources. The natural heat of the inner earth, or geothermal energy, has been used for many years as a heat source. This energy was first used to produce electric power in 1904 in Italy and is still in use. Yet the potential for using this energy stored inside the earth is significant. The National Petroleum Council has estimated that if a concentrated effort is applied to geothermal technology, by 1985 the United States could be producing between 19,000 and 132,000 MW of power. By comparison, the current capacity of all nuclear plants in the United States is about 34,000 MW.



There are three types of geothermal energy, all of which are thought to exist in Texas. As heat flows toward the surface from the center of the earth it warms rock formations. The heat contained in these hot rocks can be used to generate electricity. Water is circulated through wells drilled in the hot rock. As the water circulates through the wells it flashes into steam which in turn drives a turbine. In some cases, the deposits of very high temperature water already exist and be used directly for electric generation (such as The Geysers in California). These two sources are considered renewable energy sources. The third type, a geopressured source, also consist of pockets of high temperature water. It is not considered, however, a renewable source since there is generally not a continued water supply and the pressure must be released for power generation.

The geothermal potential of Texas is particularly interesting because of the possible rapid development of the resource into electricity production.

Of the three, the Gulf Coast area offers the greatest possibility for short range production. This area is thought to be a band of geopressured sands which run along the Gulf Coast at depths from 700 - 20,000 feet. Large pockets of extremely hot, highly pressured water may have been trapped in these sands and have continued to absorb heat from the earth over time. The pockets, with temperatures ranging between 325 degrees to 400 degrees Fahrenheit, have been sealed within the sand formations. When these pockets are punctured, the water rushes to the surface where at normal atmosphere pressure it flashes into steam which can then be used to produce electricity. An added advantage of these geopressured areas is the methane which is thought to be dissolved in the waters. This methane can be extracted and used to supplement existing natural gas supplies. Although it is not yet known to what degree the withdrawal of this water may contribute to subsidence, it is hoped that the water will be fresh and will not have to be reinjected but instead can be used for agricultural irrigation.

Although the geopressured coastal regions of Texas are considered a depletable resource, initial estimates range from a production capability of 22,000 MW for 20 years to 22,000 MW for 50 years to even higher. This does not include the added value of natural gas and potable water. As research quickens and technology advances, the potential of geothermal energy in Texas becomes more and more a possibility.

*Texas Energy Report, January, 1975.

WIND

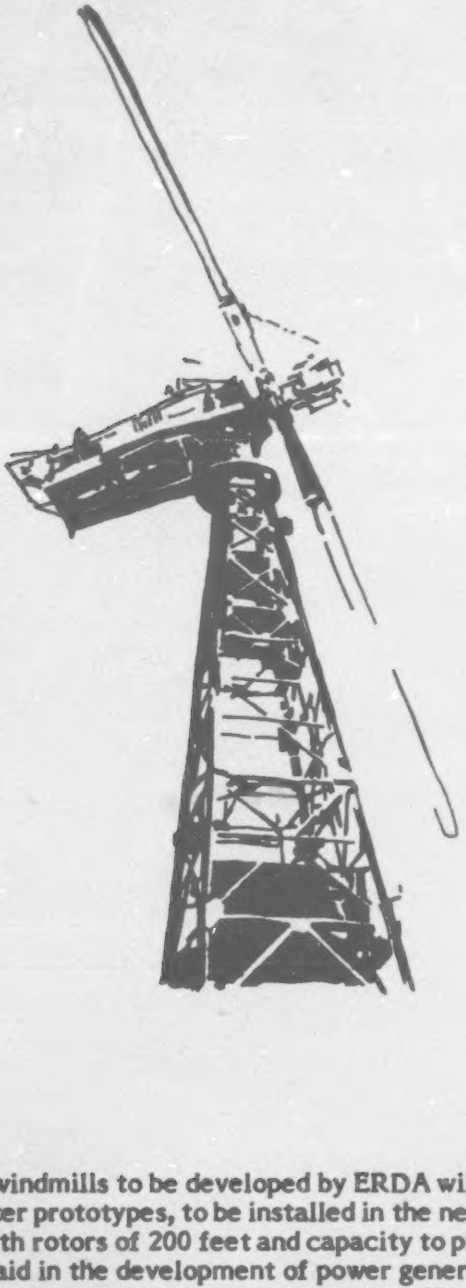
Harnessing the wind has been the dream of man for centuries. To some extent it has already been done -- on a small scale. Since the mid 19th century, many small windmills have been built and used in the United States to pump water, generate electricity, and perform similar functions. To date it is estimated that over 150,000 small windmills are in operation in this country.

Now, as a result of funding by the Energy Research and Development Administration, large power generating windmills may be developed for the first time in over 30 years. Of 65 suggested sites, ERDA has selected 17 locations for consideration, Texas being among them.

Southwestern Public Service Company, Amarillo, was among the 65 utility firms submitting proposals to ERDA for the windmill project. Two pilot windmills will be designed to generate between 125 and 200 KW of electricity in winds of about 20 miles per hour.

At present, ERDA is conducting two wind studies, one in New England and the other in Hawaii. These studies are meant to determine what standards should be set for operational wind power generation by commercial utilities such as Southwestern Public Service Company.

ERDA believes that wind energy conversion systems are not yet cost effective. A spokesman for ERDA states that with improved wind generators and eventual mass production the chances of their becoming cost competitive with other energy conversion systems are very good.

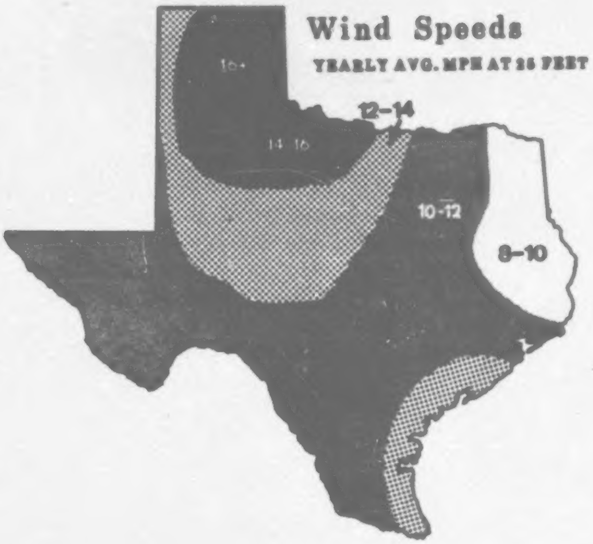


The first set of windmills to be developed by ERDA will have blades of about 125 feet in length. Later prototypes, to be installed in the next two to three years, will be even larger, with rotors of 200 feet and capacity to produce 1,500 KW. The project is intended to aid in the development of power generating windmills which will supplement existing electric generating systems, but not provide the only source of electricity generation.

In 1973, the National Aeronautics and Space Administration along with the National Science Foundation jointly appointed a committee which suggested that by the year 2000 a major American development program in wind power could result in an annual yield of 1.5 trillion KWH of electricity. That is equal to the total electricity consumption in the United States in the year 1970.

A conference sponsored by NASA and NSF on Wind Energy Conversion Systems in June of 1973 resulted in the discussion of important general areas of wind energy. These general areas included: important past developments, rotor characteristics, wind sighting problems and wind characteristics, energy storage, energy conversion systems, small wind power systems for remote and individual applications, tower structures, and wind power systems for large scale applications.

The topographic character of Texas, particularly the Panhandle, provides many favorable situations for wind power installations. Data from the National Weather Service Stations in Texas indicate that most of the state has a wind energy potential significantly greater than almost all other regions of similar size in the nation. The economic benefits to the state and the importance of the contribution to the Nation's total energy resources are obvious.



Not only can wind energy conversion systems be developed and utilized for direct electric generation, but many researchers are studying ways to develop systems to utilize the natural resource for numerous other applications.

At West Texas State University, in Canyon, a grant has been awarded to Dr. Vaughn Nelson, Dr. Earl Gilmore and Dr. Robert Barieau to conduct a study to determine the feasibility of using wind power to pump water for irrigation on the High Plains.

The research will involve simulating on a computer a complete wind energy conversion system to project the cost benefit ratio for the High Plains of Texas. Analyses will further influence decisions which can be made concerning wind power as an energy source or as a supplement to other energy sources.

Dr. Earl Gilmore, an Amarillo College professor, states that the program consists of two parts: "One of the problems of designing wind rotors or props of optimum efficiencies is to design them in a fashion that will allow them to do certain types of jobs. It is this type of thing that will be done on the computer." The other area of the project is concerned with the modeling of a system and with the characteristics of all the important parameters associated with the operation of various pumping systems which can be designed to be driven by wind rotors and other associated components.

Other research into wind energy conversion has already been conducted at West Texas State University. These include: the heating and cooling of residential homes and other rural structures, the production of electricity, the production of fertilizer, the conservation of water by developing closed systems, and the development of vehicular propulsion.

Research into the heating and cooling systems for homes and other rural structures revealed that a wind driven heat pump could transfer heat from a source to a reservoir. It is also possible to add solar energy to the existing system. Incorporating an auxiliary solar system would tend to improve the performance characteristics of the existing wind unit and heat pump. A cooling effect could be obtained in the summer by using the evaporator end of the system. In this system, direct wind energy can be used because only mechanical energy is needed to drive the heat pump.

Electricity production research utilizing wind energy has resulted in a number of techniques and methods being used to develop direct current power. Electric vehicles could benefit from a system of this type. Production of hydrogen and oxygen by electrolysis of water is another phase of research directly related to the production of electricity through wind energy conversion.

In the production of fertilizer, high voltage discharges can be created to aid in the production of nitrogen oxides from air. Also, the collection of ammonia from electrolytic hydrogen and nitrogen separated from air can be produced with this process.

Current studies dealing with methods of conserving water by developing closed systems show that wind energy can be used to compress air from inside structures such as greenhouses. Solar heat can be trapped and liberated by compression as the atmospheric moisture condenses to water. The compressed air can be used to operate air engines or to produce cooling by re-expansion to atmospheric pressure. The condensed water can be used in the electrolysis cell.

In vehicular propulsion research, electric vehicles are under study, along with hydrogen powered vehicles.

With the development of new materials over the past years and the advances in aerodynamics associated with rotor design, many of the major obstacles to building large diameter wind energy conversion machines have been overcome. Perhaps, most of the current helicopter rotor technology is applicable to wind energy conversion systems. This could mean that defense contractors and even the space industry will be in the forefront of advanced design and production of large wind energy conversion units.

Because wind energy is of low density and because it is an intermittent source of energy, the major problem after the power is produced is how to store it. Research in this area is primarily concerned with the development of various types of batteries, storage pumps, and flywheels.

Up to now, the only long term successful utilization of wind power has occurred in rural settings. Perhaps the logical way to increase levels of utilization of wind energy is to use this past knowledge and experience in future developments.

Not only does the Texas Panhandle possess a high wind energy potential, but areas along the Gulf Coast are also potentially capable of utilizing wind energy conversion systems. When all aspects are considered, the use of wind in Texas is unlimited. The fuel cost is zero and cannot increase. The resource is inexhaustible; therefore the problem of resource depletion cannot arise. The resource is unaffected by embargo, transportation problems, and employee problems. Water is not required for the capture and utilization, and wind power can even provide energy at the most remote locations in the state. One of the highlights of wind energy conversion is that there is a minimum of pollution involved.

With all the favorable aspects of utilizing wind as an energy source, there are still a few unfavorable aspects. Energy intermittence, low density of the resource itself, and high initial cost of mechanical equipment and research are perhaps the areas of most concern at this time. These have effectively limited wind power utilization in the past, and as long as inexpensive storage is unavailable intermittence poses a severe problem in the utilization of wind energy by electric utilities.

Perhaps, in the not too distant future Texas will reap benefits from one of its most obvious and ever present natural resources. If economics and technology permit, harnessing of the Texas wind will become a reality.

*Texas Energy Report, August, 1976.

SOLAR

Two small North Texas towns are pursuing their plans to be among the first American cities to have part or all of their electric power generated from solar energy. The two communities are Crosbyton and Bridgeport. Crosbyton, population 2,500 is located 38 miles east of Lubbock in an irrigated farming area on the High Plains. Bridgeport is a town of just under 5,000 population located 45 miles northwest of Fort Worth.

At press time, neither project had received an assured source of funding although both expressed optimism.

Both projects offer unique departures from other techniques designed to produce electricity from solar energy. Because of a variety of circumstances, the Bridgeport project, in particular has been the subject of nationwide news media attention.

CROSBYTON -- Like most of the state's electric generating facilities, the municipally-owned Crosbyton power plant is fired by natural gas. In 1973, the plant was subject to numerous curtailments and the price of gas began to escalate. Power production costs tripled between 1973 and 1974.

Realizing that a continuation of these trends threaten the ecomonic viability of the Crosbyton area, a series of town meetings were conducted in May, 1974 with the City's engineering consultant and Texas Tech University experts.

After some deliberation regarding the City's available options, the decision was made to go solar. At the suggestion of the Institute for Energy Research and the Department of Electrical Engineering at Texas Tech, Crosbyton opted for a relatively new concept called the Fixed Mirror Distributed Focus (FMDF) arrangement conceived by E-Systems and Helio Associates.

E-Systems, Inc., of Dallas is the world's largest supplier of ground based and radio telescope systems. Helio Associates, Inc. of Tucson is involved in mirror and lens design and solar engineering techniques. To promote the project, Crosbyton Solar Power, Inc. was chartered by the State on April 10, 1975 as a non-profit corporation.

The ultimate goal of the Crosbyton project is the construction of a 5 megawatt capacity solar plant. Cost of the entire project is estimated at about $20 million.

Funding for the project is being sought from the U.S. Energy Research and Development Administration (ERDA). Texas Tech University Professor of Engineering John Reichert is listed as principal investigator in the funding proposal.

The project is broken into two phases. The current request before ERDA is for $2.5 million for a 30-month detailed design study including the construction of a 50-foot diameter collector and absorber. Based on the results of the data obtained from the Phase I studies, Phase II would entail the actual construction of the 5 MW plant at an estimated cost of $17.5 million. Completion of the power plant would require about two years following the 30-month Phase I studies (no sooner than early 1981.)

The City of Crosbyton proposes to donate one half section of land (320 acres) for the plant site and has offered the use of its current plant and electrical system for experimentation and back-up. Once the plant is operable and functioning, it would become the City's baseload plant. The present gas-fired generator would be used as a back-up in case of a failure in the plant or storage mechanism.

At press time, the Texas Tech researchers and Crosbyton city officials were awaiting a response from ERDA on their Phase I proposal.

BRIDGEPORT -- Like Crosbyton, the City of Bridgeport owns its electrical system but, unlike Crosbyton, does not own generating facilities. The City purchases electrical energy from Texas Power and Light Company (TP&L).

In June of 1975, TP&L asked the City for an 11.25% rate increase. TP&L had raised its rates by 87% since mid-1972 and the Bridgeport City Council refused to grant the 11.25% increase insisting instead on a 4.2% rate increase. After several months of negotiating, the City continued to hold firm with the 4.2% offer. After the last council vote on the issue, November 3, 1975, TP&L announced that it would discontinue service to the City in November, 1978 -the earliest possible date permitted by contractual agreement.

The prospects of a small town being cut off by a large utility apparently had considerable news appeal. (In actuality, it is unlikely that the state Public Utilities Commission would permit the abandonment of service to any community.) The Wall Street Journal and national news services carried the story. Shortly, Solar King, Inc. of Reno, Nevada -- a small firm dealing mainly in solar collector production -- responded offering to build a solar power plant for Bridgeport. The prospect of a solar plant was greeted very enthusiastically by the entire community. This, in turn, resulted in another flood of national press exposure including network television. The City Council has been showered with letters from all over the nation and as far away as South Africa. Some have included small donations for the solar plant. Several engineering firms have contacted the City Manager to offer their services.

Brian Pardo, President of Solar King, made a proposal to the City to build a 6 MW plant at a cost of only $6 million (about $1,000 per kw).

While the Bridgeport project has been riding the crest of intense news media publicity, a cloud of controversy threatens to mar the success of the venture. In February, a Dallas area man named A.J. Darwin of Darwin Foundation Ltd., offered $2.5 million in matching funds for the construction of the solar plant. Shortly afterward, Dallas newspapers carried stories noting that Darwin faced hot check charges and a variety of civil judgments.

About the same time, Bridgeport city officials received a letter from the Pillsbury Company of Minneapolis stating that the company intended to begin a statewide fund raising effort for Bridgeport. Later, top corporate officials at Pillsbury disclaimed the letter noting that an overzealous employee had taken it upon himself to organize the fund raising and had used Pillsbury stationery to make the offer.

Meanwhile, several experts had reviewed Solar King's technical proposal and expressed skepticism regarding the claims for the collector, storage and heat engine efficiencies.

City officials in Bridgeport are undaunted by the skeptics and are optimistic that the Darwin and Pillsbury funding assistance will materialize. A solar power plant fund has been established in the First National Bank of Bridgeport and a finance committee has been established in the Chamber of Commerce to oversee the fund.

An ERDA official says that the agency is taking a two-pronged approach to the situation by considering 1) a proposal from Solar King for a detailed engineering analysis of the complete Solar King system and 2) a study of various applications of solar technology for the City of Bridgeport. An Oklahoma City engineering firm, Benham and Blair, has volunteered its services to Bridgeport until ERDA funding is forthcoming.

If the studies are funded, and if the signs are positive, it is possible that ERDA would provide funding for construction of a prototype Solar King plant in Bridgeport. Without a massive private funding effort, it is highly unlikely that the plant will be constructed by 1978.

TECHNICAL CONCEPTS -- To put the technical concepts proposed by the two projects in perspective, it is appropriate to quickly review the three most common methods of harnessing direct solar energy: 1) photovoltaic conversion 2) direct heating and cooling 3) central power station solar thermal conversion.

(1) **Photovoltaic Conversion:** This is the process of transforming sunlight directly into electricity through the use of solar cells. The crystal silicon cell invented in 1954 is currently the most developed type. Sunlight strikes the individual cells connected in series to produce direct current. Although solar cells produce electricity in space craft and in isolated areas of the world, the technology needs a 30-to-40 fold increase in efficiency before it can compete economically with currently-accepted forms of electricity production.

(2) Heating and Cooling: Approximately one quarter of the energy consumed in the U.S. is used to heat and cool buildings and provide for water heating. The sun's heat can, and is, being used to provide most or all of the energy needed in a number of buildings around the world. For some applications and in some areas, solar heating and cooling is already cost effective (i.e., cheaper over a period of a few years than gas or electrical systems). Given current trends in fuel cost and availability, solar heating and cooling could become commonplace within a decade. In Texas, there are several solar heating and cooling projects in operation, under construction and being planned.

(3) Central Power Station Solar Thermal Conversion: Most conventional power plants (one big exception being hydroelectric) involve the production of high pressure steam in a boiler by burning fossil or nuclear fuels. The steam drives a turbine, which, in turn, spins a generator to produce the alternate current we use to power our homes and businesses. Conceivably, solar energy could be used to drive the generator -- either through a heat engine or through the steam turbine cycle described above. The leading conceptual design for solar electric generation is the solar tower concept in which acres of mirrors are used to focus their rays on a boiler to produce steam. Perhaps the greatest problem facing proponents of the solar tower concept is the storage of power in periods of cloudy weather or darkness. Both the Crosbyton and Bridgeport projects are categorized as central power station solar thermal conversion plants. However, both represent significant departures from the solar tower concept. The Bridgeport project is by far the most revolutionary in that it avoids the steam turbine process entirely. Also, in utilizing low-grade heat to drive a heat engine (which spins a generator), the problem of energy storage is reduced.

CROSBYTON -- Fixed Mirror Distributed Focus (FMDF) - This concept, proposed by Crosbyton, utilizes a fixed hemispherical collector to concentrate a linear image of the sun on an absorber. The absorber is attached to a boom which is pivoted by a mount to follow the sun's motion. A heat transfer medium is used to power a turbine.

The FMDF concept claims several advantages over other solar electric generating techniques. These include fewer moving parts (only the receiver tracks the sun as opposed to hundreds of mirrors), simple maintenance, minimum use of untested technologies (E-Systems has constructed a similar optical dish as a radio telescope), easy storage in bad weather, and minimum visual impact.

The final price tag of $20 million would probably include some form of thermal storage to provide energy inputs during darkness and cloudy weather.

BRIDGEPORT -- The Solar King Concept - The Bridgeport project as conceived by Solar King would not utilize a steam turbine to generate electricity. Instead, it would produce power to drive a generator by means of a heat engine.

Solar King proposes to build a solar plant using flat plate collectors to produce a low grade heat rather than high temperature steam generation. The hot water (average about 180 degrees Fahrenheit) would be stored in insulated tanks beneath the collector field. Hot water from storage and cold water (from either wells or Lake Bridgeport) would pass through individual heat exchangers on an alternating and sequentially timed basis. The resultant expanding and contracting of a working fluid in turn would drive a series of discs and pistons to power a low-rpm, high-torque drive system. The drive shaft from the Solar King thermal engine would power an alternator which would be connected to an existing transformer.

Specifically, Solar King estimates that four thermal engines rated at 1.5 MW each would be needed to produce a net capacity of 6 MW. Each 2,000 horsepower engine would require 2,000 collectors (each covering about 28 square feet) and a one-million gallon storage tank. Therefore, in total, some 8,000 collectors would be needed in an area of about 12 acres. This storage system is designed to provide energy for up to 100 hours of no sunlight conditions in January with doubled reserves in summer.

The Bridgeport project differs from the Crosbyton project in that flat plate collectors would be used to collect low grade heat. Flat plate collectors, unlike focusing collectors, collect diffuse radiation and are not solely dependent on direct, cloudless sunlight. The problem of energy storage is greatly reduced by the use of low grade heat. Finally, the new Solar King thermal engine claims much higher efficiency than standard heat engines -- a level of efficiency which some experts claim defies the laws of thermodynamics.

ECONOMICS -- The true significance of the Bridgeport and Crosbyton projects is not whether they are technically feasible to construct but whether they can be constructed and operated at reasonable costs.

Reasonableness is relative -- relative to costs of other fuels. Traditionally, Texas power plants have been fueled by natural gas because gas was readily available and cheap. Also, gas-fired plants are the least expensive to construct.

The Texas Railroad Commission has recently prohibited any new contracts for boiler fuel gas and has mandated a scheduled reduction for large boiler fuel gas users through 1985. Oil, like gas, has become increasingly scarce and has more than quadrupled in price over the past few years. In short, Texas utilities must and are turning to alternate sources of energy.

For the immediate future, coal and nuclear are the chief alternatives to oil and gas because they are technically proven and are presently more economically attractive.

However, the current trend of sharply rising fuel and construction costs, coupled with potential breakthroughs in solar technology could lead one to speculate that solar might become competitive with oil and gas within a matter of years rather than decades.

According to Leonard Reichle, Vice President for Nuclear at Ebasco Services, Inc. (one of the nation's major nuclear plant engineering firms), the cost of building a nuclear reactor has risen from $300 per kw in 1970 (national average) to $1,135 in 1975. During the same period, fossil fuel plant costs have risen from $220 to $950 per kw. (Construction costs for Texas plants have generally been lower than national costs.)

Much of the increased costs for coal and nuclear are the result of a need to provide for adequate protection from environmental and safety problems not associated with solar energy.

Supporters of the FMDF concept (Crosbyton) believe that in mass production FMDF plants can be constructed at "substantially less" than $1,000 per kw. The Solar King figures for the Bridgeport plant indicate plant costs of $1,000 per kw.

The figures cited above are strictly calculations from undemonstrated technologies. Based on these calculations, the magnitudes of cost are approaching competitiveness in plant construction.

The capital costs of construction are only a part of the economic equation. Uranium and fossil fuel prices have doubled, tripled and, in some instances, more than quadrupled during the 1970's. The trend is for even higher costs in the future. By contrast, solar energy is free and limitless.

Nevertheless, most utility executives remain doubtful that solar will supplant coal and nuclear anytime soon. J. F. Skelton, president of Texas Power and Light believes that the commercial feasibility of solar-powered electric generation is still two decades away. He argues that even if Solar King's cost figures are correct, the plant would cost three times as much as the lignite fired plants his firm is constructing in East Texas. He also states that the interest costs alone on the Solar King plant would cost Bridgeport ratepayers more than their total current prices.

The proponents of these two projects and other solar electric projects in the nation do not attempt to justify their proposals on today's costs alone. They base their case on future costs and the inevitable depletion of our non-renewable energy resources.

*Texas Energy Report - March, 1976

PYROLYSIS

Pyrolysis. While the word seems to conjure up itchy scalps or other medical infirmities, in fact, pyrolysis is one of the most promising technologies for converting agricultural, industrial, or municipal wastes to oil, gas, and low-sulfur solid fuels.

The word is derived from the Greek roots PYR (Fire) and LYSIS (Loosening). Pyrolysis is best defined as the decomposition of organic material caused by the application of heat in the absence (or near absence) of oxygen.

The conversion to energy of the billions of tons of solid waste produced annually in the U.S. together with the recycling of noncombustibles (glass, aluminum, ferrous materials) would dramatically reduce environmental pressures associated with waste disposal and supply a large fraction of our energy needs.

However, because the production of waste materials - particularly agricultural wastes - is scattered over a wide area, most experts believe that at best solid wastes should not be expected to contribute more than two or three percent of our national energy supply.

Nevertheless, solid wastes are now being used as a fuel supplement in several sites in Europe and the U.S. to supply on the order of 10 percent of the energy used to produce electric power.

Most of the so-called first generation waste conversion facilities involve either the simple incineration of garbage to create low grade steam or the use of shredded organic material as fuel supplement to coal-fired power plants.

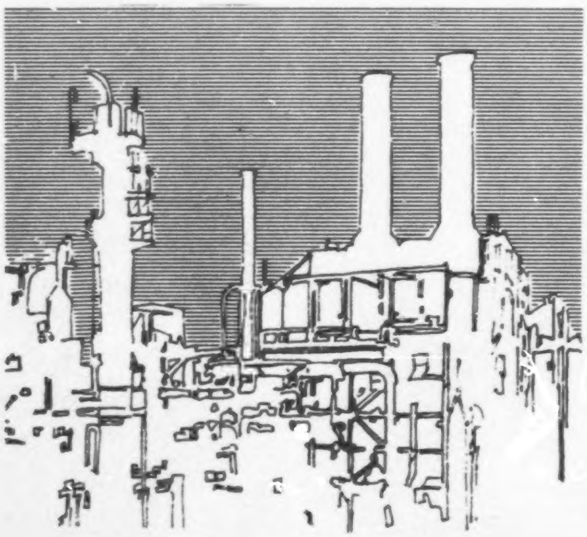
There are several pyrolysis operations in various stages of research, development and demonstration throughout the nation. Two Texas projects at opposite ends of the State bear watching.

Researchers at Texas Tech University in Lubbock are converting cow manure, found in copious quantities in area feedlots, into various synthetic fuels, including ethylene--an important feedstock for the petrochemical industry. Near Baytown, a 20-ton-per-day demonstration pyrolysis plant is nearing completion. Its builders are hoping the plant will demonstrate a significant breakthrough in the waste conversion process, which will result in efficient and economic conversion plants for both large and medium sized communities.

Texas Tech Research

A group of researchers headed by Dr. William Huffman at Texas Tech University are developing a pyrolysis process which produces a variety of useful chemical products from cow manure.

The project is supported by the U.S. Environmental Protection Agency, the State of Texas, Pioneer Natural Gas, Phillips Petroleum, Southwestern Public Service Company, and the Texas Cattle Feeders Association. The project started in 1971 when Dr. James Halligan and Dr. Robert Sweazy of Texas Tech concluded from preliminary calculations that manure could be converted to an ammonia-synthesis gas. A two-foot laboratory model proved that their process did, in fact, produce ammonia-synthesis gas, a product used in the manufacture of fertilizer.



Ammonia is currently produced from natural gas, accounting for approximately 4 percent of the nation's gas consumption.

Last summer, a larger prototype plant was put into operation. The plant, which was not yet completed, unexpectedly produced not only ammonia synthesis gas but a large volume of ethylene. Ethylene, the most widely used organic chemical in the world, is used in the manufacture of plastics.

Through variations of time and temperature, the Synthesis Gas From Manure (SGFM) process can produce various proportions of ammonia synthesis gas, methane (the major component of natural gas), ethane and ethylene. Because ethylene currently sells for about $5 per million BTU, or more than twice the unit value of natural gas, ethylene is the most desired product.

At present, the prototype plant at Texas Tech can process one half ton of manure daily. A commercial operation would need to process several hundred tons per day.

As with all waste recovery processes, the economics of SGFM are dependent on a variety of factors, including capital and operating costs, availability of feedstocks, and markets.

Obviously, the SGFM process is particularly attractive to Texas because of the State's large cattle feedlot and petrochemical industries.

The Texas Tech researchers calculate that each beef animal will produce about one ton of manure per year. The SGFM process yield about 180 pounds of ethylene per ton of manure.

Huffman and Halligan have sketched an outline of the economics of a commercial size plant using the SGFM process. The hypothesized commercial operation would require an initial investment of $30 million, with annual operating costs of $8 million (including debt retirement and $2 per ton delivery costs of manure).

The annual income from the sale of ethylene (at 12¢ per lb.) would amount to $8,400,000. Ammonia synthesis gas sales (at $41 per ton for ammonia) would amount to $5,425,000. The estimated net profit after taxes would amount to about $2,912,000. or a 9.7% return on investment.

The authors feel that these figures are on the conservative side.

The locational requirements of the commercial plant include close proximity to some 500,000 cattle, an existing ammonia plant and an existing product pipeline. These three criteria are best met in the western Panhandle of Texas near the cities of Dimmitt and Hereford which boast the largest concentration of feed cattle in the nation.

Another advantage of this area is the low humidity. Naturally dried manure provides considerable energy savings in the preprocessing stage.

Because of the unique set of circumstances existing in the High Plains area, the Tech researchers have concentrated their efforts on a process adaptable to the local situation. They point out that the SGFM process can be used for other organic wastes as well.

Wallace-Atkins Process

For more than 15 years Lyle Atkins, a Houston inventor, has been working to perfect a process for converting organic wastes into usable energy products. Much of this time has been spent attempting to persuade industry, financial institutions, and government to finance the construction of a plant to demonstrate his proprietary process.

For the most part, Atkins' efforts have been met with skepticism or offers by industry to buy the patent rights (the patents have been applied for).

Atkins, who teamed up with fellow inventor Floyd Wallace to form Wallace Atkins Oil Corp. several years ago, states that his pyrolysis process is more energy-efficient and less costly than other processes developed by research teams in large corporations.

In February of this year, Atkins announced that a 20-ton per day plant using the Wallace-Atkins process was being constructed near Trinity Bay southeast of Baytown. The plant, which is expected to be complete this year, (1976), is designed to demonstrate the use of a variety of feedstocks ranging from old tires to Texas lignite.

The cost of the plant is about $400,000, or $20,000 per daily ton--a figure well below that of other first-of-a-kind demonstration plants for pyrolytic processes. J-Mar Energy, Inc. was incorporated early this year to construct, own and operate the plant. R.W. Johnson, a construction fabricator for the petrochemical industry, is the principal contractor for the project.

According to Atkins, the purpose of the plant is twofold:

1) To serve as a demonstration for the Wallace-Atkins process, and
2) To operate on a commercial basis.

Atkins believes the economics of the process are sound enough so that the sale of products from the plant will amortize the cost of the plant within three years. For commercial operations the plant will utilize waste wood products which are currently being landfilled.

The continuous feed operation, according to Atkins, will produce a near-pipeline-quality gas, which will be flared, and a high grade char. The char has already been contracted for sale to an undisclosed heavy industrial user.

Atkins calculates that from each 20 tons of wood waste he can produce 8 tons of char and 200 MCF of gas at 800 BTU per cubic foot.

For several years Atkins has operated a 100-pound (batch) pilot plant which produces oil, gas, and char. Tests by an independent testing laboratory show that the process recovers approximately 97 percent of the energy value of the waste input. Atkins estimates that an equivalent of 10 percent of the recovery energy would be needed for heat and electricity to power the process. If he is correct, the resulting net energy efficiency would run about 87 percent. This compares at best to a 70 percent figure for other pyrolytic processes.

Basically, the process is as follows: Heat is applied to shredded solid waste in an oxygen-free environment converting organic material to gas. The proprietary catalytic reactor, which involves the creation of a high frequency energy field in metal alloys, converts the steam fraction into free hydrogen and oxygen. Condensation tanks collect the liquid fraction. (The Baytown plant will gasify all of the crude oil produced.)

The solid char can be used for a variety of purposes, including charcoal briquettes. For municipal solid waste, the metals, glass and other non-organic materials can be mechanically recovered from the char.

If the Baytown plant proves to be a commercial success, Atkins believes the technology could be utilized by cities all over the nation as an alternative to current waste disposal techniques.

Last November, Atkins contracted with the City of Alvin, Texas for a $2 million 100-ton-per-day plant. The 30-year contract calls for Alvin Energy Corporations (Atkins and Associates) to construct and operate the plant. The City is obligated to deliver all of its solid waste to the plant at a fixed rate of $3 per ton. Currently, landfill costs for Alvin and adjacent cities amount to about $7 per ton.

Alvin and other southeast Texas cities are running out of landfill space, therefore the prospects of fixing disposal costs at $3 per ton for 30 years are obviously attractive.

Atkins calculates that the pretax profits for the sale of the oil, gas, char, and recovered metals will approximate $22.50 per ton. This excludes financing charges and the $3 per ton tipping fee.

Thus far, Atkins has not found the $2 million needed to build the plant. However, if the economics of the process are proven in the Baytown plant, pyrolysis may have taken a long step toward fulfilling its potential as a source of energy.

*Texas Energy Report - May, 1976

1975 ENERGY PRODUCTION IN TEXAS

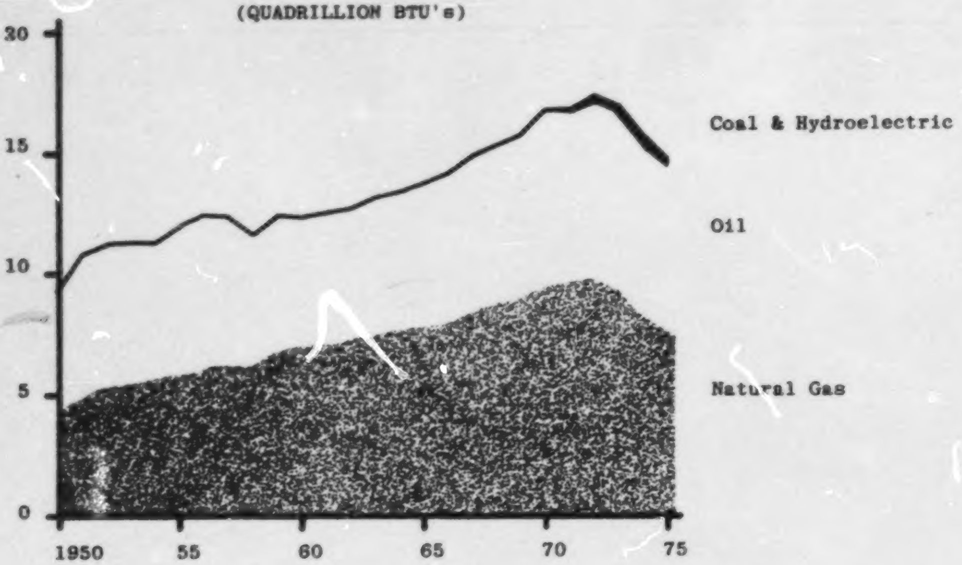
In 1975 Texas recorded its third straight year of declining energy production. Total oil, gas, lignite, and hydroelectric power produced was 14.83 quadrillion BTU's (quads), a 5.8% drop from the 1974 production figure of 15.74 quads.

During 1975 crude oil accounted for 48% of all the energy produced in Texas. The daily production of 3.35 million barrels was a 3.2% decline from 1974's production rate of 3.45 million barrels per day. Oil production peaked in Texas in 1972 when 3.57 million barrels were produced each day.

In 1975 Texas natural gas production declined 8.1% to 7.5 trillion cubic feet. Yet gas still was the largest energy source, accounting for 51% of total energy produced. Texas gas production peaked in 1972 at 9.6 TCF - 18.5% above current production levels.

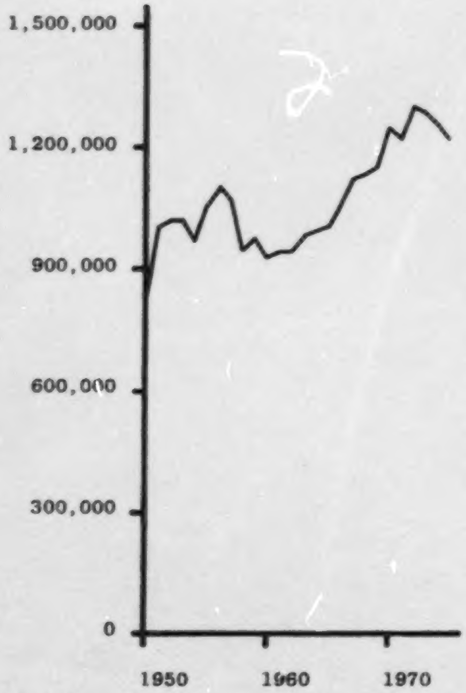
TEXAS ENERGY PRODUCTION

(QUADRILLION BTU's)



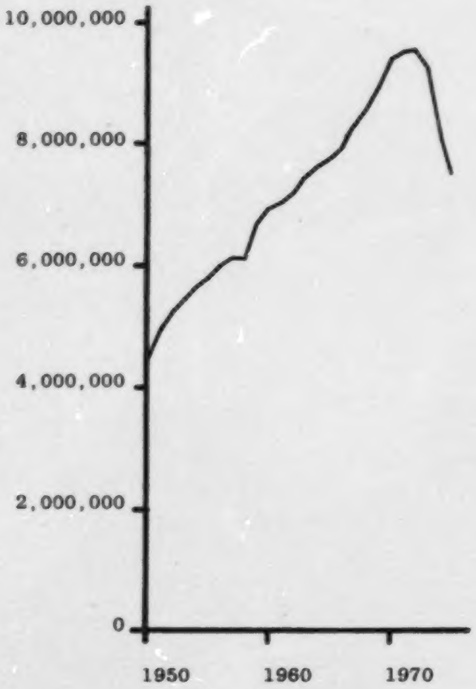
TEXAS CRUDE OIL PRODUCTION

(THOUSAND BARRELS)



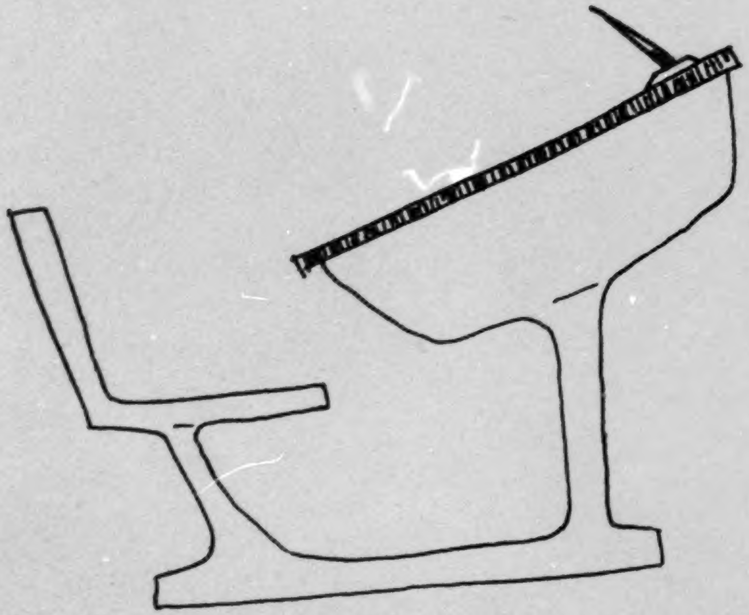
TEXAS NATURAL GAS PRODUCTION

(MILLION CUBIC FEET)



Lignite, which accounts for 1% of the total energy produced in Texas, also registered a decline in 1975 - slipping 4% from 1974's figure of 8,377,000 tons. Only hydroelectric power, which accounts for less than 1% of total energy production, showed a gain in 1975.

*Texas Energy Report, May, 1976



MORE ACTIVITIES

OTHER ACTIVITIES

METER READING
(Math, Science: adaptable to all levels)

TYPE OF ACTIVITY: Meter Reading Lesson

1. The dial-type meters may be integrated into primary math to reinforce grouping concepts.

2. Students may try to figure out why pointers on adjacent dials rotate in opposite directions. Intermediate or older students may attempt to secure an old meter from a local utility company to disassemble.

3. Build a model kilowatt meter out of tagboard, styrofoam, wood, etc. Work out a gearing system so that adjacent dials rotate each other in a ratio of 1:10 (left to right).

INSULATION
(Social Studies: Gr. K-3, 4-6)

TYPE OF ACTIVITY: Exploration

ENERGY AREA: All energies used for home heating

MATERIALS NEEDED: Small quantities of various kinds of insulating materials demonstrator or materials to construct demonstrator thermometer

DESCRIPTION OF ACTIVITY:

1. Students develop a list, from research or background, of all the insulating factors in the home.

2. Secure or build an insulation demonstrator.

Guidelines for building:
Small and portable (about 12" x 12" x 18").
Heat with light bulb(s).
Provide one or two windows.
Construct of ⅜" plywood and 1½" framing.
Floor - Single thickness plywood with provision for adding insulation.
Walls - Double construction, one piece to be easily detachable to add or change insulation.
Ceiling - Essentially a lid which serves as a shallow tray to hold insulating materials.
Window-Include provision to install "storm" windows (a second pane with air space between the two).

3. Devise as many variations as possible of testing different insulating materials and combinations thereof.

(Use temperatures both inside and immediately outside the demonstrator.)

4. Assemble a product file on various materials.

5. Tabulate consumer prices on various materials.

6. Compare advantages and disadvantages, including per dollar value on various materials.

7. Make a class study of the ways in which homes represented are deficient in insulation.

8. Secondary students might be able to use data thus far derived to predict kwh's or BTU's conserved by correcting various deficiencies.

ELECTRICALLY POWERED TOYS
(Social Studies: Gr. K-3, 4-6)

TYPE OF ACTIVITY: Exploration

ENERGY AREA: Electricity

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

1. Students bring to school electrically powered appliances and toys which function solely in recreation or entertainment. Have class discussion to:

   a. Avoid duplications;

   b. Decide whether or not battery-powered items should be included.

2. Students attempt to research for each item such questions as:

   a. How long has this item been on the market?

   b. Was it marketed to fill a need, or did its appearance on the market, along with advertising, create its own need?

   c. If it indeed fills a need, can we think of alternative diversions which require no energy consumption? These may already exist, or could be created by the students.

   d. Explore what the children in colonial days used for recreation. Did they have the same needs for recreation as we have today?

RELATED ACTIVITY:

By observing at local department and stationery stores, students make a list of games, puzzles and diversions which are commercially produced versions of activities that can be done (and have been for years) with no materials, or common household items (pencil and paper, a few marbles, toothpicks, etc.). Have students discuss why sale of these items is successful. Older students may be able to relate this to generic principles that underlie attitudes regarding the general American lifestyle-affluence, materialism, status, prestige, etc.

GASOLINE CONSERVATION THROUGH CAR POOLS
(Interdisciplinary: Gr. K-3, 4-6)

TYPE OF ACTIVITY: Exploration, Discussion

ENERGY AREA: Gasoline

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

1. Make a survey (through class discussion of family practices or by actual count along a busy street at a rush hour) of vehicles transporting the driver only.

2. Discuss as many ways as the children can think of (bring ideas from home) to reduce "driver only" trips. Examples:

   How many boys in a neighborhood are transported to a scout meeting?

   Could several neighborhood mothers combine their marketing trips?

3. Out of as long a list as you can make, rank the ideas in order of practicality, and devise a plan to actually implement those kinds of car pool ideas which seem most likely to work. Involve parent clubs.

RELATED ACTIVITIES:

1. Have students keep record of the number of times (in one week, one day, etc.) that several trips from home have been made in the family car when, with planning, one trip might have been sufficient. Compile class results.

2. Have students do creative writing relative to gasoline rationing or curtailment. Example:
   "How would life in my family be affected if our gasoline supply were cut in half?"

3. Compute class totals or averages of "unnecessary mileage" before and after conservation plan is implemented. Show comparisons on line or bar graphs.

4. Collect data on gas prices. Determine rate of gas cost increase over a given period of time. Research reasons.

5. Learn to compute miles per gallon.

USING FEWER WATTS AT HOME
(Math, Social Studies: Gr. 4-6)

TYPE OF ACTIVITY: Exploration

ENERGY AREA: Electricity

VOCABULARY: Electrical Appliance, Watt

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

1. Class makes the longest possible list of electrical appliances found at home and school.

2. Find out how many watts each uses and include this on the list. (This can be discovered by looking on the appliance. If it is not given, parents or teachers may compute the watts by the formula: watts = volts x amps.)

3. Have the class discuss which appliances are used the most. How many of these have high wattage figures?

4. Let the children decide which of the appliances they think their home or school could do without or use less often. The children could discuss this with parents and make curtailment plans.

5. Following a predetermined time period (one day, one week, etc.), have the class make a list of all the appliances their homes have done without or used less often.

RELATED ACTIVITIES:

Average kilowatt hours used before and after the curtailment can be computed and illustrated in line or bar graphs.

ENERGY USE TIME DISTRIBUTION
(Social Studies: Gr. 4-6, 7-9, 10-12)

TYPE OF ACTIVITY: Exploration, Discussion

ENERGY AREA: Electricity

MATERIALS NEEDED: Record keeping sheets

SKILLS NEEDED: Electric meter reading

DESCRIPTION OF ACTIVITY:

Premise: Electrical energy is not "stored," but produced as needed.

1. Through discussion of current life styles, family activity patterns, etc., predict the hours of peak demand.

2. If possible, on weekends or by special assignment arrangements, have several teams or individuals read home meters hourly over a given period of time. Compile results as a class. Compare with predictions.

3. Explore ideas to spread some of the demands of the peak hours to periods of lighter demands. Concentrate on ideas that students themselves might implement; i.e. deferring television watching to different hours.

4. Report to class which ideas worked and which seemed impossible.

5. Explore ideas of how entire communities might juggle schedules to even out the electrical demand hours.

RESEARCHING COMMUNITY COOPERATION IN VOLUNTARY ENERGY USE CURTAILMENT

(Math, Science, Social Studies: Gr. 7-9)

TYPE OF ACTIVITY: Exploration, Discussion

ENERGY AREA: Electricity

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

1. Assign teams to observe in the community:
   Restaurants
   Grocery Stores
   Gas Stations
   Manufacturing Companies
   Schools
   Public Buildings and Parks
   Homes
   Motels and Hotels

2. Observe the obvious things that have been done to reduce energy: lights, signs, etc.

3. If possible, when they are not too busy, interview some of the managers of these establishments to find out

other ways they may have reduced energy use that are not obvious to you as an observer.

4. Have each team assemble a report of their study to present to the class.

RELATED ACTIVITIES:

1. Does it appear that most businesses and homes in the community are cooperating with the request to conserve energy?

2. Do you feel it is important that all areas of the community should be asked to cooperate to conserve? Why?

3. Did you observe or think of any more ways that energy could be conserved without seriously affecting that business or home?

REDUCING HOME KILOWATT HOURS

(Math, Social Studies: 7-9, 10-12)

TYPE OF ACTIVITY: Exploration, Problem Solving

ENERGY AREA: Electricity

VOCABULARY: Watt, watt hour, kilowatt hour, volt, ampere, average

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

1. Through discussion, students develop a list of all appliances in the home which consume electricity. From this an inventory sheet is published. Each student takes this home and keeps a complete 24 hour record. Compute total KWH's. Determine average per family unit.

2. Class results are compiled into a composite showing totals.

3. Based on discussion with parents, plan priorities for usage.

4. Predict and compute the kwh savings.

5. Attempt to implement the plan for a given period of time (24 hours). Repeat inventory if necessary.

6. Develop graphs, charts, etc., showing the original average per family kwh consumption, the predicted savings, the actual savings, and a projection for a neighborhood or community of a given size.

RELATED ACTIVITIES:

Art department may produce posters illustrating the project and display in store windows, etc.

GASOLINE CONSERVATION THROUGH DRIVING HABITS
(Math, Science: Gr. 7-9, 10-12)

TYPE OF ACTIVITY: Exploration, Problem Solving

ENERGY AREA: Gasoline

MATERIALS NEEDED: Data survey sheets

DESCRIPTION OF ACTIVITY:

1. Use a class survey to gather the following data (use larger samplings if possible).
    a. Average automobile miles driven in one week.
    b. Average miles per gallon of family cars.
    c. Percentage of drivers that use "jack rabbit" starts at traffic signals. (Assign teams to observe and tally at several typical traffic light intersections.)
2. Automotive Information (September 1973) states that fast starts can increase gas consumption as much as 18 percent. Using data gathered, compute the amount of gallons of gasoline consumed by the families represented by the class. (Assume that the percentage found in item 1.c. is typical and applies to this group.)
3. Possible Extentions of this Activity:
    a. Find a per family average: compute the savings for the community.
    b. Find the community's annual savings.
    c. Research the accuracy of your averages.
    d. Develop graphs, posters, etc., to dramatize your findings. Display them in windows of local businesses willing to participate.
    e. Similar projects could be done with other known fuel topics, i.e., vehicle operating condition, most efficient driving speeds, vehicle weight as it relates to miles per gallon.
    f. Discussion problems:
        1. A delivery man gets $5 per hour in wages. His truck gets 18 miles per gallon if he

drives 50 mph but only 11 miles per gallon if he drives 60 mph. On a 500 mile trip, at which speed should he drive in order to make his trips as economical as possible?

2. Can a person lose weight by turning down heat in his home?

3. Does it cost more to light one 100 watt bulb or two 50 watt bulbs for the same length of time?

CONSERVING ENERGY USED TO HEAT WATER

(Math, Physics: Gr. 10-12)

TYPE OF ACTIVITY: Problem Solving

ENERGY AREA: Electricity

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

I know a person that insists that three inches of water in a tub is adequate for bathing, but many people fill the tub to a depth of ten inches. How much electric energy is required to bathe in this luxury?

SOLUTION:

Assume the water is heated from 40 degrees Fahrenheit (≈4.5 C) to 100 degrees F (≈37.7 C).

NOTE: $$(C) = \frac{5(F-32)}{9}$$

Assume also that a tub holding water to a depth of 10 inches contains 189,000 c.c. of water.

NOTE: 1 cubic inch = $(2.54)^3$ cubic centimeters

To compute the watt-hours of electricity use the formula:

$$(\text{watt-hours}) = \frac{4.18\ (\Delta C)\ V}{3{,}600}$$

$$= \frac{4.18\ (33.2)\ (189{,}000)}{3{,}600}$$

$$= 7{,}285 \text{ watt hours}$$

How long would this amount of energy operate a 50 watt bulb?

ENERGY CONSERVATION IN HOME HEATING
(Social Studies, Science: Gr. 10-12)

TYPE OF ACTIVITY: Problem Solving

ENERGY AREA: Any used for home heating

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

Compute the difference in the amount of heat required to heat a house to 70 degrees rather than 65 degrees if the average winter temperature is 45 degrees.

The amount of heat required for a given house increases with the square of the difference between the inside and outside temperature. For example, if the temperature outside is 60 degrees, and the inside temperature is 70 degrees, the difference, 70 degrees - 60 degrees = 10 degrees. If the outside temperature drops to 50 degrees, the difference then is d = 70 degrees - 50 degrees, or 20 degrees.

Heat required = K d^2, where K is the constant depending upon the size of the house, how well it's insulated, etc. (Assume K=1)

Heat required when the temperature is 50 degrees is four times that required when the temperature is 60 degrees, since $20^2 = 400$ or four times $10^2 = 100$.

SOLUTION:

D_1 = 65 degrees - 45 degrees = 20 degrees

D_2 = 70 degrees - 45 degrees = 25 degrees

The heat required at 65 degrees

$H_1 = K\ 20^2 = 400\ K$

The heat required at 70 degrees

$H_2 = K(25)^2 = 625K$

Therefore, the amount of heat required to heat to 70 degrees is

$$\frac{625\ K}{400\ K} = \quad 1.5625$$

1.5625 times that required to heat to 65 degrees, or 56% more.

If H is heat required, d is temperature difference, or inside temperature minus outside temperature.

$H = f(d) = Kd^2$ if $K = .05$ graph the function $H = .05\,d^2$

Discuss the significance of this in terms of fuel savings.

LIFE-STYLE AND ENERGY CONSERVATION

TYPE OF ACTIVITY: Discussion, Research

ENERGY AREA: Energy and goods consumption in general

MATERIALS NEEDED: None

DESCRIPTION OF ACTIVITY:

Premise: The general long-standing attitude that raw materials and energy sources are inexhaustible have led most Americans to become overconsumers and energy gluttons.

Premise: Psychologists and common sense tell us that there is a close correlation between a pleasant, well-designed environment and a sense of personal well-being.

1. Consider the two premises above. Students may wish to accept, reject or revise either or both.
2. To what extent do they conflict with one another?
    a. Students select (preferably as a group) a man made mini-environment (a classroom, a church, a home, etc.) which they agree is reasonably pleasant and well designed.
    b. Students make as complete as possible an inventory of the manufactured items in the environment selected.
    c. Select a few of these items (such as vinyl, metal or wood trim on a chair, wheel discs of hub caps on automobile, etc.) to consider the following:
        (1) To what extent does it contribute to the pleasantness or good design of the mini-environment?
        (2) Have we been influenced by industry which produces the item to think that it is essential?
        (3) Conduct an energy flow study on the item. Consider the energy required to extract the raw material, transport it, refine it, transport it again, and all other steps leading to the end product.

        (4) Attempt to extrapolate the total BTU's involved in what might be the total annual consumption of this item.

    d. Consider the elimination or modification of this item in terms of the "Pleasant environment" concept.

        (1) Suppose the class agrees the item could and should be eliminated. Could the same rationale apply to many other goods designed to enhance our environment?

        (2) In what ways would this affect the nation's economy, labor market, etc.?

ADDITIONAL INVESTIGATIONS

1. Research. Students in technical and vocational courses are encouraged to explore alternative energy sources such as wind generators, solar furnaces, solid waste energy converters, ways of harnessing wave action, tides and geothermal energy. These and other areas are wide-open frontiers.

    a. Students may construct prototypes of energy producing devices utilizing wind and/or solar power.

    b. Methods must be devised to tie such devices into present energy sources.

    c. Prototypes could be displayed and demonstrated in places such as shopping centers, or any place that will attract public attention.

    d. Sudents may wish to explore the efficiency factors of present energy consuming devices such as the internal combustion engine.

2. Service Pool. Students who have the suitable background, interest and enthusiasm may serve as resource persons:

    a. To elementary and secondary schools in any energy-related curricular area.

    b. To educate private citizens to read their kilowatt hour meters and implement practical voluntary curtailment plans.

    c. To be available on call to perform free services such as lowering hot water thermostat settings.

3. On Campus Assemblies. Present programs utilizing students who have specialized in particular areas of energy research, or outside speakers.

ADDITIONAL TEACHING SUGGESTIONS

Primary Grades

1. Make a list of all equipment in the schoolroom that is powered by electricity.

2. Ask the custodian to come into the classroom and explain how electricity helps him in his work.

3. Make a science display of items that are powered by electricity for classroom use.

4. Schedule a field trip to the home to look at the ways electrical energy is used there.

5. Ask parents to come to the classroom and discuss how they use electricity in their work.

6. Look at the wattage on light bulbs, read the wattage figures, add the amount used and compare home consumption with classroom consumption.

7. Read power consumption data on appliances. (Consult custodian or local electrician for assistance,)

8. Make a display chart showing how much energy is consumed by each.

9. Make a reading experience chart containing statements about the conservation of energy.

10. Introduce the spelling of words associated with electricity:
    a. watts
    b. volts
    c. bulb
    d. motor
    e. plug
    f. wire

11. Study parents' occupations and determine how a shut down in electrical consumption would affect each job.

12. Make a bar graph comparing the amount of electricity consumed by one device with another (light bulb, electric mixers, stove or hot plate, popcorn popper).

13. Begin to explore techniques of electrical energy measurement. Watts and volts are new concepts that must be introduced at an unsophisticated level.

14. Ask students to express their views about conserving electricity in a one-page paper. Provide them with a key word list.

15. Begin to explore the interrelationship of weather and the energy crisis in Texas.

16. Develop a vocabulary of terms associated with energy.

17. Let children create projects (paintings, models, etc.) which require a minimum of commercially produced materials (paper, glue, crayons, etc.

18. Make a display of disposable products (use once and discard) which waste natural resources in terms of raw materials and energy to produce.

Intermediate Grades

1. Ask students to explain why people do not wish to do without those convenience items that consume electricity.

2. Ask students to detail the occupations that provide services which are essential to the survival of a community and how those services consume electrical energy (water pumping stations, sewage treatment plants, scheduling of transportation services).

3. Study the ways electrical energy is produced in the state.

4. Study home consumption of power and determine which appliance is the largest user. Ask your local utility to help the class find out which industry, plant or single consumer is the largest single user of power in the community. Does this user benefit the community?

5. Carry out an essay competition entitled "How Can Energy be Saved in the State of Texas?"

6. Introduce the formulas for power consumption, transmission, and generation. Some science programs present these formulas at this grade level.

7. Discuss reasons why electrical energy is preferred to other kinds of energy for given jobs (clean, easily transported, easily maintained equipment, etc.).

8. Discuss whether existing sources of energy have been utilized intelligently in the state of Texas. Some sources are not used? Why? (expensive, environmental trade-offs too high)

9. Visit some electricity distribution centers. Ask the engineers to explain how electrical energy is distributed. Visit an oil tank storage area, a natural gas control center, etc.

10. Distribute leaflets to homes in the neighborhood, describing the power shortage and indicating ways the children have identified as reasonable methods to conserve power.

11. Ask permission from a local radio station for students

to conduct a talk show, featuring ideas on how local citizens could conserve energy.

12. Arrange for students and school administrators to work together to find ways to save energy within the school.

13. Compose short stories or plays around possible results of energy failure, or the energy conservation effort.

14. Write articles, poems, cinquains, haikus, dealing with energy for publication in the school newspaper.

15. Correspond with students in other schools to compare conservation efforts.

16. Collect newspaper and magazine articles on the energy crisis. Use them to discover and graph trends, make bulletin board displays, or for a college or mobile in an art project.

Junior High Level

1. Study available sources of energy fuels. What is the generation capacity in various areas of the United States, and the per capita earnings for individuals in those areas?

2. Ask each student to investigate one form of energy, its long-term strengths and weaknesses as an energy source and its effect on the local community, state, and nation.

3. Discuss with students why individuals are reluctant to give up their conveniences.

4. Construct models of generating facilities (steam, hydro) and determine their efficiency.

5. Study power transformers, their design, use and long-term effectiveness.

6. Study the relative efficiency of methods used to transport electricity.

7. Produce a chart illustrating the development of a given source of power and its delivery to the consumer.

8. Measure the calories consumed when people exercise. How much food is required to provide a given amount of calories?

9. Explore efficient ways to use foods available locally.

10. Discuss the efficient purchase of those foods which require less energy for production (i.e., human effort, fuel for transport, effort of retailers, etc.).

11. Compare products to find those which most efficiently carry out designated tasks (i.e., a small car may serve two people as well as a large car; a home which is large enough for your family may serve as well as a larger house).

12. Explore effective use of appliances which have been purchased to better the family standard of living.

13. Investigate the effects of available energy supply upon the standard of living in various areas of the United States during the past 40 years.

14. Given a curtailment of energy in the local community, determine which energy consumers should receive first priority. Discuss the criteria used in making these judgments.

15. Study the ways people have been motivated to use more energy in the past. Discuss the possibility of reversing the trend from promotion to reduction of energy consumption.

16. Draw a map showing the sources of fossil fuels in the United States. Discuss how they were formed and present mining techniques.

17. Study the construction of a nuclear electrical generation facility and the process used to generate energy.

18. Compare forms of energy generation to find which are presently economical and which are not. Find the reasons why some forms are not economical.

19. Given an opportunity to work with small engines, find the amount of fuel a small engine consumes when it is out of tune, compared to when it is properly adjusted. Measure on a time basis at a given r.p.m.

20. Compare total energy considerations in the use of hot air blowers which have replaced paper towels in many public washrooms.

21. Determine through weather records of the past year (or years) how many days clothes could have been dried out of doors rather than in a clothes drier. How many kwh does this represent in your community? How many gallons of water does this represent in the hydroelectric reservoir?

High School Level

NOTE: Consider a mini-course for the high schools on the energy crisis. It would be designed for the junior or senior year with a 45-hour instructional time block. Concepts introduced in the elementary grades would be expanded and developed.

1. Determine those events in the last 50 years which have led to utilizing greater amounts of energy. Was the impact on an international, national, state or local scale? For example, building a national network of freeways; advertising that bigger cars are better; lighting streets for safety, assuming that more they are lighted the safer. Many more events can be named and their implications explored.

2. Ask students to evaluate the purchase of a home from an energy consumption point of view (i.e., insulation, cubic feet, storm windows, effective heating system, length of hot water lines and their insulation, etc.).

3. Compare the rental and operational costs of apartments to the purchasing and operating cost of homes. Relate energy consumption in these dwellings to the number of cubic square feet in the residence, the temperature at which the area is maintained, the square feet of uninsulated glass in the residence and other possible factors.

4. Find which types of clothing retain body heat and remain comfortable in a residence or working place with a reduced temperature. Include clothing that is used for work as well as dress.

5. Compute the alternatives to vehicle ownership. Explore car rental possibilities. Relate car size to particular needs. Determine potential repair and maintenance costs of vehicles. Explore the fuel consumption of different modes of transportation.

6. Investigate the local and statewide political implication of the power shortage. Will people vote against public officials whose actions tend to reduce present convenience? What positions are being taken by elected officials?

7. Introduce young people to the idea of growing some of their own foods, purchasing local foods in season and preserving them, and in other ways making best use of the resources around them. Discuss the most efficient methods of food preservation.

8. Discuss the kind of campaign that would be most effective in reducing electrical energy consumption. Who should pay for the campaign? Is this a negative kind of educational effort (i.e. urging people not to use something)?

9. Post hypothetical problems regarding the energy crisis, such as: "Government has mandated a 50% reduction in electrical, petroleum and natural gas consumption." Instruct students to establish priorities and work out a

solution.

10. Make a study of the effect of lowered urban and highway illumination on crime and vandalism.

11. A recent news report stated that large quantities of scrap aluminum are being exported. Compare the energy cost of recycling scrap aluminum to that of producing from bauxite.

ALL-SCHOOL ACTIVITIES FOR ENERGY CONSERVATION - CREATING ENERGY CONSCIOUSNESS

The school provides many opportunities to assist with the energy crisis outside of the classroom. This section provides suggestions for all-school activities in two categories: 1) student activities which will stress awareness of the energy crisis; and 2) actions which can be taken by occupants of a school building to conserve energy.

We urge school principals to undertake the responsibility of organizing the all-school effort, distributing these materials to appropriate personnel, assisting in the organization of related activities, and encouraging individual contributions from teachers, staff and students. The following ideas may be of some assistance in organizing activities for Energy Conservation.

School Assemblies. A number of local authorities are available to tell students what they know about the energy crisis and energy conservation. One good contact for such speakers is the local public or private utility company that serves the school. These companies have special employees available to resource lists of community groups and individuals. Utility companies also have films and filmstrips available for school use.

Valuable information resources on the energy crisis probably exist right in your school. Teachers and students can organize an effective assembly by relying on debate teams and forensic clubs, drama groups and specialists in related areas of science, home economics, shop, etc.

Information campaigns. The most important aspect of energy conservation is getting people informed about: 1) energy crisis conditions, and 2) actions which might improve those conditions. The following activities can assist in the statewide information campaign.

School Paper. The school paper might contain weekly stories on energy supply conditions and efforts to conserve energy. A valuable source of information is the Governor's Energy Advisory Council.

Energy Crisis Information Center. Help students organize an energy crisis information center in your school. They might collect information for the classroom, organize lists of references and speakers, provide conservation tips to students for their homes, etc.

Community Information Campaigns. School clubs and/or classrooms may want to organize information campaigns that reach into the community such as: 1) weekly residential checks on energy conservation, 2) a campaign to discourage electric Christmas displays, and 3) a survey of the economy measures being adhered to by local business and industry.

Competitions Related to the Energy Crisis. School competitions can add a little excitement to the business of spreading energy crisis information. Several schools have already organized poster competitions. Other ideas for competitions are: 1) slogan contest, 2) song contest, 3) essay competition, 4) speech competition, 5) conservation suggestion list contest, and 6) outstanding class project list. Organize a competition between schools for greatest percentage of energy conservation (ground rules would have to insure health and safety measures).

Activities for Special Interest Groups. Encourage special clubs and organizations to think up their own way to contribute to energy conservation. Some suggestions are listed below:

Rally teams. Make up "save it" yells and slogans for games.

Forensic Clubs. Prepare speeches related to the energy crisis and make speakers available to the community.

Science Clubs. Look for new ways of conserving energy and provide information to school papers.

Service Organizations. Prepare signs listing conservation measures to be posted in appropriate areas (office, hallways, etc.). Organize a system to monitor electricity use in the school.

Special Save-Energy Day. Plan a special school day for minimum energy use. Keep records to derive average energy consumption by the school for a given time period, in the areas of transportation, heating, lighting, etc. Within the limits of safety and good judgment, plan a day which might involve some of the following: 1) no electrical AV equipment; 2) cold lunch (sacks or prepared by cafeteria staff); 3) no electrical clocks, bells, or intercoms (use whistles and runners); and 4) let students and faculty brainstorm for further ideas. Make it a challenge, a backward journey through time to colonial days. Dream up a title (example: AMEC Day-Absolute Minimum Energy Consumption Day) for use in publicity, before and afterward. Determine, in discussion with students, the activities that would be practical to put into daily practice.

Participation in Statewide Energy Crisis Events. A number of organizations are in the process of planning information exchange activities related to the energy crisis. Teachers and students can contribute to these events by attending conferences, preparing helpful and informative material, etc.

In order to reduce consumption of energy in the home, the following steps are important:

1. Ascertain the general principles of energy conservation;
2. Translate these principles into specific activities, and
3. Determine whether or not these actions were effective.

This section provides tools for this process: 1) General Tips for Home Energy Conservation; 2) A Home Checklist for Energy Conservation; and 3) A Lesson in Reading Electric Meters.

GENERAL TIPS FOR HOME ENERGY CONSERVATION

DETERMINE THE IMPORTANCE OF "CONVENIENCE." Today's homes are stocked with countless objects which we commonly refer to as "modern conveniences." Some conveniences greatly increase comfort and efficiency in the home (refrigerators, water heaters); others, like electric toothbrushes and power tools, merely cut down on the amount of physical energy required to do a certain job. Try to determine which home conveniences would be most expendable in a severe energy shortage.

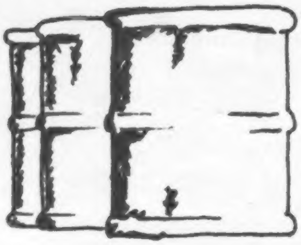
IDENTIFY THE BIGGEST ENERGY USERS. In order to save energy efficiently, it is important to know which appliances use the most energy in the home. The greatest energy use is for home heating and water heating.

The energy required to heat homes represents about 57.3 percent of all home energy consumption. Good insulation can markedly reduce this percentage. Heating water consumes about15 percent of all energy used in the home. Water heaters are usually out of sight and we don't turn them on and off like other appliances. Reducing the temperature control on water heaters can increase energy savings.

To determine the biggest energy users in the home, rate electric appliances on a scale from one to ten. Make "savings reminder" labels for home appliances. Electrical equipment that requires only nominal kilowatt consumption would, of course, be labeled in the "one" category. Big power-meter accelerators, such as clothes dryers and color TV's, would be rated at 5, 6, 7, or higher on the scale.

MAKE ENERGY ECONOMY A DESIGN PRINCIPLE. When remodeling homes, consider the energy factor in the changes you are making. For instance, most home lighting is incandescent. Fluorescent light is generally twice as efficient as incandescent lighting, and may be used effectively in baths, laundries, kitchens and workshops. Types of insulation will effect home heating efficiency. Develop a list of new equipment which might be wise to consider in home remodeling.

CONCENTRATE ON FUEL SAVINGS WHEN USING FAMILY CARS. The most recent nationwide crisis in energy supply has been the shortage of gasoline. Motorists can improve driving economy by reducing the weight carried in the vehicle (heavy tools and equipment), keeping the vehicles in peak operating condition, maintaining constant speed in city driving, etc. In addition to these specific actions, a general change in transportation habits will also improve fuel economy. Develop a list of ways that families can shorten the distance they travel in their cars.



ELEMENTARY

INDIVIDUAL OPTIONAL ACTIVITIES

1. Draw a map of your house. Put an "X" at the place where a light switch is in each room. Put an "O" at each place where there is an outlet. For one week, check electric lights and appliances at least three times a day for wasted energy. How many did you find in one week? Make a guess how long each appliance was on beyond the time it was actually needed.

2. Make a list of all the things in your house that use electricity. Make a class list.

3. Walk around your neighborhood and discover as many energy wasters as possible. Make a class list. What can you do about it?

4. Bring an energy picture to class. Write a poem about it.

5. Find out how far it is from your home to school. Try to figure out how far it is for each of the following: shortest, longest, quickest and safest.

6. Draw or make a model of the flow of oil from ground to refinery. Where does it go next?

7. Make a list of plastic packaging at home and in a grocery store. What is plastic made of? Are there better resources for packaging?

8. Make an energy crossword puzzle.

9. Figure out all the ways water affected your life yesterday. Do you see a pattern?

10. Write a commercial about water as an energy source.

11. Research how oil is manufactured by nature. When did man start using oil from the ground? How many barrels each day? Today? Predictions on how long it will last. Then what?

12. Learn something new about the energy crisis. Make a poster and share with a classroom of younger children. Ask them to tell you what it says.

13. Find information on the electric automobile. Why is it being developed? What are the problems?

14. Gather information about nuclear power generators.

15. Make a junk sculpture using cast-off or expended energy sources.

16. Tape record some sounds of energy being used. Can others identify them?

17. Go outside and find joy in your environment. Is energy involved in any of these? List them. Share your list with a friend.

18. Plan a transportation system for your city for the year 2000. What effect will it have on energy use?

19. Write or tape an imaginary interview with an historical figure from the past about comparing energy uses today with his time.

20. List all the "energy users" that you personally own or use, such as radios, toys, appliances, etc. In this list, state the type of energy required, such as AC power battery, wind-up spring, etc. After completing the list, compare it with the items a student might own in a nation which uses less energy, such as India. Try to list the "energy users" the Indian child might use.

21. Identify ways of extending the life of the crude oil supply. Basically, this is done by reducing consumption. Take it from there!

22. The student will go to the kitchen of a school or home and itemize the utensils or equipment that aid in the changing of one form of energy to another. Can you design a utensil that will do the same work as one you saw at school but which is not as wasteful of energy?

23. Assume that a definite amount of energy will be alotted to meet all your physical and psychological needs. Assume that amount of energy is about half of that which you presently consume. How would you modify your life style to conform to the energy available?

24. Assume the amount of all energy resources available to this country were cut in half. The student will list the ways in which life in this local community would be affected.

25. The student will design 12 lapel buttons with slogans that will inform people about the need to reduce the use of energy.

26. Assume that all oil deposits in the U.S. became exhausted by the year 2025. List the jobs that would be eliminated as a result. Discuss what that means in terms of vocational planning for your children.

27. The student will research the life styles of the Australian aborigines, the Eskimos and the Kalahari Desert tribes. What are their energy resources? What might that mean for us if we are faced with severely restricted energy resources? How would the student modify his life style? Justify the choices.

28. If it is true that some packaging is non-essential, and is thereby a wasteful use of natural resources (raw material and energy), what specific jobs would be affected by the elimination of excessive packaging.

    (a) List jobs affected.
    (b) Determine whether an increase or decrease in the cost of the item would result.
    (c) What problems of shipping and storage would result?
    (d) Itemize sanitary implications for ten grocery or drugstore items that are edible.
    (e) Explore other economic implications.

29. Identify the occupations that would be affected and the sources of energy that would be made more available if the principal mode of transportation in a city were to change from private automobile to mass transit (buses, trains).

30. The student will construct a chart showing the transition of vegetation from plants to coal.

plant material: peat—lignite—bituminous coal—anthracite coal

Time, heat and pressure

Describe how man uses each of the items in the chart.

31. The student will construct a model that constitutes "the good life" which can be used as background for making judgments concerning energy-resource use, considering both himself and others.

32. Make up an optional activity of your own.

CLASS AND SMALL GROUP ACTIVITIES

1. Make a mini oil slick in a pan of water. FIX IT! How many other ways can you develop to fix it?

2. What things can you personally relate to that would be useless without electricity? What would life be like without electricity?

3. Plan strategy to keep an ice cube from melting in the classroom for as long as possible. What does it mean? How many other ways work?

4. How cool can we make the schoolroom and be reasonably comfortable? Identify individual tolerances.

5. Each student bring in 5 unique pictures showing some energy use. Divide into teams and make a collage using all pictures. Classify the pictures into categories you determine, and make a statement explaining your classification system.

6. In groups, identify some of the sources of heat used by people around the world. Why do they use those sources?

7. Individually, identify some misuses of energy at school and at home. Compile a list of common misuses; develop a plan to make a difference.

8. Choose any plastic container. In small groups, brainstorm a list of as many different uses as possible that might be made of it. Who has the most? Identify most creative ideas. How does plastic relate to an energy source? Where does plastic come from?

9. Keep a record of the garbage your family throws out over a seven-day period. Weigh or measure the dimensions of the garbage and divide the total for the

week by the number in the family. Multiply this average by the number of people living in your community. List on the board those items you can recall that were potential sources of energy.

10. As a class project, build a fully functioning windmill and show the variety of uses the source of energy can provide and determine its limitations.

11. The students will describe desirable limitations of individual energy use. How does individual use of energy affect others? If we stopped using energy, how would that affect others?

12. Which fuels contribute more undesirable pollutants than others? Which fuels are most desirable to use?

Assume a perfect fuel would:

_____ be unlimited in supply
_____ be equally distributed throughout the world
_____ present no technological problems
_____ be highly efficient
_____ present no aesthetic problems
_____ have no adverse impact on the environment

The student will select the fuel he feels is the most nearly perfect fuel and defend this choice. Debate and/or discuss the pros and cons of the many fuels selected by class members.

13. The student will research and prepare presentations for each of the roles presented below:

You are a large distributor of oil in a metropolitan area. You are located in an area accessible to the transportation facilities listed below. You wish to transport the oil to your distribution plant with maximum efficiency and the least adverse effects on the environment. Representatives from the following transportation facilities present their "sales pitch" to you and your directors:

(a) railroads
(b) trucks
(c) freighters
(d) pipelines

Which means will you choose and why?

The students will, on a world map, locate important sources of energy fuels and major energy users.

14. Make a list of energy sources that are used without being changed to help you, such as:

(a) floating logs down a stream

(b) flying a kite
(c) sailboats

How important are these kinds of energy sources in our lives?

15. The students will read their home watt-hour meter and school watt-hour meter daily for one week (month?). Discuss the comparative energy consumption. Graph the results.

16. To conserve gasoline, pretend that a decision has been made to reduce the amount of gasoline available for automobiles in this country. What priorities and regulations would be needed to accomplish this as fairly as possible for all citizens?

17. Under what conditions is it fair for the United States to use 25 times as much of an unrenewable resource as another smaller underdeveloped country?

    The students will assume the roles of representatives of the United Nations. Argue before that body for a fairer share of the world's resources.

18. The students will participate in a spelling bee that uses words about energy: potential--kinetic--heat--light, etc. How many of these energy words can you define?

19. List energy-conversion products (heat, gas, water, light, electricity, torque, noise, work, etc.). The student will choose one, then play a role in which he assumes the identity of that product. Get together with another "product" unlike himself and decide how he would like to be treated as society disposes of him.

    Present conclusions to the class.

20. What considerations should be made when members of your family purchase major electric appliances? Ask what influences their selection of brand, size and model? Ask whether the amount of electricity required is considered?

21. Make a list of their personal belongings acquired during the past two years which use energy. List those things they would like to acquire. What's a list like this good for? Do you see any trends in your purchases?

22. The local stores have all announced that due to a transportation strike there will be no more candy bars for an extended period of time. What will happen to the present supply? How will the supply be distributed? Will there be restrictions as to how many bars each person will be permitted to buy? What will happen to the price? What will happen to you emotionally if there are no restrictions and someone ahead of you buys the

last box of bars? What will you be willing to do to get some of those bars? Now, relate this scenario to an energy-related problem.

23. The students will compare the sources of energy available to people living in the continental U.S., and compare the uses of energy by people living in:

(a) Hawaii
(b) Australia
(c) Japan
(d) Egypt
(e) India
(f) Alaska

24. Three elements of the "good life" are:

(a) desirability of work and school environments
(b) desirability of home environment
(c) desirability of recreational environment

With these in mind, please respond to the next 3 tasks:

(1) List all energy-consuming devices needed for each environment and for transportation to each environment.

(2) Describe the location in terms of the most desirable climate, landscape and population.

(3) If a model city were to be built, locate it on a map. Could energy be transferred there, reasonably, from present sources?

25. The student will describe ways to minimize bad effects of obtaining energy resources:

(a) coal (mines, strip mining)
(b) oil (derricks, pipelines, offshore)
(c) gas (pipelines, pumping stations)
(d) wood (clear-cutting, transporting)
(e) electricity (considered as a fuel)
(f) nuclear fuels (mining)

The student will describe the aesthetic effects of mining, refining, producing and/or delivering:

(a) coal
(b) oil
(c) gas
(d) wood
(e) hydroelectric energy
(f) nuclear-generated electric energy

26. From the following items, the student will list the energy consumed by each in its production and in its use. If the student had to cut his energy consumption

drastically, which of these could he replace easily? Which would be more difficult? Which would be impossible?

- Electric lighting
- Electric cooking
- Electric heat
- Water heating
- Air conditioning
- Mixer
- Washer
- Dryer
- Synthetic fiber clothing
- Wood frame house
- Automobile
- Stop lights
- Street lights
- Prefab house
- Aluminum siding
- Power lawn mower
- Steam shovel
- Electric toothbrush
- Power saw
- Plastic modular furniture
- Dishwasher
- Television
- Radio
- Stereo system
- Road graders
- Tractors

27. For Middle School Students

Student should go to the Library and find the latest information (millions of tons, percent total) for the following sources of air pollution listed in the table below.

U.S. Air Pollutant Emmissions

Source of Air Pollution	Millions of Tons	Percent of Total
Automobile	_____	_____
Industry	_____	_____
Electric Power Plant	_____	_____
Space Heating	_____	_____
Refuse Disposal	_____	_____
Total	_____	_____

After filling in the information for the table above the student will respond to the following questions.

(a) Which source is the single greatest contributor to air pollution?

(b) How does air pollution of all autos compare to the total of air pollutants contributed by industry, cluster power plants, space heating and refuse disposal?

(c) If a railroad "coal" car could hold a load of about 50 tons, how many railroad cars full of pollutants were put into the air?

Fun math question: If a railroad car were 50 feet long, how long a train would be necessary to carry all the air pollutants?

28. In order to help children understand the concept of a "trade-off", ask them to plan an imaginary trip to Disneyland using the following information:

In groups of 4 or 5, the students will pretend they are going to Disneyland. Select their method of transportation, what they will eat, and what they will do at Disneyland. Plan the trip with a total of $120 to spend.

How to get to Disneyland?

	Time	Cost	
Car	16 hrs	$9.80	
Train	10 hrs	17.25	one way
Plane	3 hrs	31.75	

What to do at Disneyland?

All exhibits and rides cost $1.50 each. (List what type of energy is used for each.) A book of 20 tickets costs $22.50.

Food? How will it be prepared and served? Where to eat? What waste will be involved?

Motel while at Disneyland--$12 per day. (Is there an alternative?)

The students must get to Disneyland and back home in three days. What will their choices be? Will they have to make any "trade-offs?" Will they spend all their money?

29. Pretend that four groups of people are going to set up housekeeping beside a common stream; their land is next to each other. They will generate their own energy. Group 1 will set up a coal-fired generating plant. Group 2 will set up a gas-fired generating plant. Group 3 will set up a nuclear-fired generating plant. Group 4 will set up a hydropowered generating plant. Join one of these groups. Each group may oppose the erection of any other group's plant on the basis of pollutants, passage of fuel across their territory, use/abuse of a common resource such as air or water.

Defend the plant of one group, but eventually you decide the best possible method of generating electricity; whether it should be a common source or several generators and which one. If a common source is selected, whose land will it occupy and how much will be paid for the land use?

30. Students will pretend they are going on a camping trip 200 miles from home. The length of the vacation is two weeks. They wish to spend as little money as possible, spend as much time in the wilderness as possible and contribute as little pollution as they can. Based on these requirements, select a mode of travel, cooking fuel, housing en route, housing at the campsite, types of activities during the period at camp.

31. The student will pick one favorite possession which is made of manmade material (plastic or synthetic fiber). Also, select a short motor trip he would like very much to take.

    Decide between the trip and the possession. Defend the choice on the basis of expenditure of fossil resources. The trip would take energy and fossil fuel, and so did manufacture of the possession.

32. The students will go on a "field walk" with a small group of other students and list all the energy conversion they see. Do it in this manner:

Object Viewed	Energy Source	Ultimate Product
Automobile	Gasoline	Motion
Light Bulb	Electricity	Light
Sailboat	Wind	Motion

SECONDARY

INDIVIDUAL OPTIONAL ACTIVITIES

1. Read articles in recent periodicals that deal with energy problems (i.e., Alaska pipeline, offshore oil, gas rationing, etc.). Make a statement on what it means to you in the media of your choice.

2. Make a list of as many wasteful uses of energy as you can detect or observe. What are you going to do with it?

3. How can you combine or interrelate activities a, b, c, and d?

   a. Make a collage expressing a good quality of life in the year when you will be 35.

   b. Make a list of the energy users in your home that did not exist in 1954. Invent a list of energy users that might be in use in 1994 that do not exist now.

   c. In 1994 many of you will probably have families of your own. How will your life style differ from your existing family's?

   d. Interview someone over 70. Have them relate to you how energy use has changed since they were children - transportation - heat - the home - school.

4. Using any media, express "Energy, where are you?"

5. Write a commercial about water. Present the commercial to an audience of your choice. What effect did it have?

6. Take pictures of the 10 biggest energy users in your community or the 10 most efficient users of energy. Imagination is the game. Now what?

7. Survey a number of automobile dealers on the following topics:

   a. Should the U.S. limit horsepower?

   b. Gas mileage.

   c. Sales trends of compact cars.

   How soon would changes in these areas be possible?

8. Research solar energy. Design a car or a house utilizing solar energy as the main source of power.

9. Draw a map of a metropolitan area and show how it might look if there were no automobiles.

10. Write a poem that could serve as an obituary for the automobile.

11. Assume that you are a candidate for the President of the United States. Write your energy platform.

12. Go outside and find a series of events involving energy, such that the first is related to the second, the second to the third, and so on—but so that the last event appears to have no causal relationship to the first. Represent these events using some visual medium.

13. How much fuel is used by:

	Month	Year	Mileage
School bus	____	____	____
Police cars	____	____	____
Postal service (local)	____	____	____
Fire department	____	____	____

What are "they" doing about it?

14. Write or tape an imaginary interview with an historical figure from the distant past about comparing energy uses today with his time.

15. Take a batch of dirty clothes and wash them in the laundromat of an area outside of where you live. Talk to other people there and find out what they think about the current energy problem.

16. On one 25 foot roll of 8mm film record as many different uses of energy as possible (enough frames must be used so that they are visible). Show to the class. How many can they identify?

17. Go outside and find things that represent power. Sketch, photograph, or in some way visually describe these things. Exchange power descriptions and compare. Then discuss what kind of power you see in each other's descriptions. What is power? How do you get it? How do you keep it? How do you lose it? How do you use it? Who has it?

18. As constraints are placed on energy use, give examples of:

    a. Potential loss or trade-off of freedom in our legal system.

    b. Change in the job market.

19. Write a proposal for a research project that will help to alleviate a forthcoming local energy problem. The proposal should include:

    a. A problem statement

    b. Clearly quantified delineation of the need

    c. Proposed hypotheses

    d. Budget

    e. Procedures

f. Personnel needs

g. An evaluation design

Find what sources might be approached for funding such a project. DO IT!

20. The astronauts use solar energy as a primary energy source when on the moon. The energy is provided by a conversion of the sun's solar energy to electric energy. This source has been suggested as an energy substitute for gasoline to provide power to autos. List some of the problems which would take place if autos were made to use solar energy. How could the problems be solved?

21. Describe possible effects on ecosystems if man uses nonrenewable energy resources to realize the proper relationships between artificial systems, equilibrium systems, and systems undergoing repair on this planet.

22. Compare the employment requirements necessary to deliver comparable energy to a customer using:

    a. Coal

    b. Gas

    c. Oil

    d. Wood

    e. Hydroelectric

    f. Nuclear electric

    g. Coal/electric

    h. Gas/electric

    i. Oil/electric

    j. Nuclear/hydrogen

23. Find some water in your environment that does not seem to be related to your life—then prove any way you can that it is!

24. List sources of energy used by men in historical sequence. Include nuclear, falling water, wind natural gas, wood, geothermal, coal, tidal, oil, chemical, solar, electrolysis by nuclear power, and other hydrogen-producing means. How are you going to present this? What does it mean?

25. Describe the political or private group which you think should control energy production.

26. Discuss the economic and occupational implications of a law that would prohibit the conversion of fossil resources to heat energy.

27. Assume one of the following is to be constructed in your community:

    a. A coal-fired electric power plant

    b. An oil-fired electric plant

    c. A gas-fired electric power plant

    d. A nuclear-fired electric power plant

    List the jobs displaced by such construction. List the jobs created by such construction. Try to describe the economic impact on the community.

28. Go to an art gallery and conduct an inventory of art objects which depict energy conversion. Explain the energy conversion being illustrated and attempt to hypothesize the original influence on the artist.

29. Select an art object, preferably sculpture, and determine the kinds of energy used to produce it. Estimate the amount of energy used by the artist. Use calorie charts to determine the energy for a man at work.

30. Energy production is affected by many agencies at the private, federal, state, and local levels. Locate the names of the agencies at each level and determine their duties and legal status. Should the system be improved? If so, how?

31. Design and make drawings of a system that could use waste to heat and cool office buildings in your city. Assume the system will burn 360 tons a day of solid waste and allow for future expansion to burn 1,500 tons a day.

32. The student will assume he is a congressman. Write a law which would restrict fuel consumption and be equitable to all sectors of society.

33. Set up the enforcement mechanisms necessary to accomplish orderly reductions in energy use.

34. Estimate the minimum amount of energy you would need for bare existence.

35. Contrast the immediate and long-term effects on the people of Saudi Arabia and Kuwait by the discovery and exploitation of oil in their countries.

36. International wars often have been fought because one

nation wanted more resources or energy. Review the wars of the world since 1900. Give examples of fighting motivated by the quest for resources.

37. The student will assume he is the mayor of his city. Describe the qualifications of the person he would hire to establish a public transportation system. Include educational background, occupational experience, political philosophy, and other factors considered important. How would he be expected to approach the problem? To whom would he be answerable?

38. Evaluate the effect on the job market of a shift to nondisposable items.

39. Among the few renewable energy resources is wood fuel. However, abuse could quickly make it nonrenewable. To prevent a total loss of wood as both an energy source and a building or shelter, public policy has required that national forests be harvested so that the forests can be renewed. Man has not always followed this policy. The student will attempt to discover which ancient and modern civilizations lost their forest resources. Discuss how the renewal of forest resources either helps or hinders individuals and societies.

40. Describe the relationship between limited energy resources and international trade.

41. Describe the relationship between limited energy resources to social systems such as political, economic and family.

42. Evaluate what is necessary to implement a domestic growth policy based on unlimited energy.

43. Investigate stock market trends and activities the last two years for three firms that produce energy products, or pollution-control systems. Make a graph of your findings. Who should see this graph? Give it to them.

44. Do you think that YOU, as a citizen, should have a say in what products private industry develops and sells?

Besides enacting laws, by what other means can the public influence what products are sold?

Where does energy fit into your decisions?

45. MAKE A STATEMENT without using words which illustrates the relationship between energy and aesthetics.

Are aesthetic considerations important in the use of energy?

What relationships can you identify between energy and aesthetics?

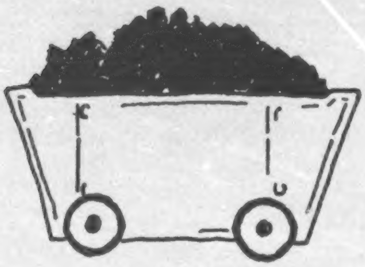
46. SCIENCE FICTION is usually laden with advanced technological machines, instruments, contraptions, services and sources and uses of energy.

Read a SCIENCE FICTION story (from an anthology) or book and keep track of some of these.

Pick ANY TWO and explain how you think they would affect LIFE in today's world. What implications about energy can you identify?

47. Make a statement about energy in our society WITHOUT using written or spoken words.

Be creative; have confidence! Your teacher will not give you any extra information. SURPRISE the class with your project--KEEP it a secret. You choose the media and the materials!



CLASS AND GROUP ACTIVITIES

1. Survey attitudes and opinions about the current energy problem facing students and adults. For example, survey five people. What do they miss most? List positive and negative feelings.

2. Assume the role of your school board. A decision must be made to cut the school year by 20 days in order to save energy. Develop a plan that will have a minimum effect on students' education and meet necessary contractual requirements as well as save energy.

3. How much governmental regulation are you prepared to tolerate concerning the consumption of energy?

Consider the following fact in relationship to your level of tolerance:

PREAMBLE

> We, the people of the United States, in order to form a more perfect union, establish justice, insure domestic tranquility, provide for the common defense, promote the general welfare, and secure the blessings of liberty to ourselves and our posterity, do ordain and establish this Constitution for the United States of America.

4. Simulate the TV program "Meet the Press." Role play reporters questioning an Energy Czar.

   Energy Czar - leave room.
   Class generate questions about critical issues right now—today.
   Reporters interact with the Czar. One student act as moderator.

5. Hold a mock trial. Charge someone or some agency with misuse of energy resources. Have judges, lawyers for and against the charge, and the class be the jury. (The topic could be Indians trying whites for their misuse of land.)

   Discuss the ethics of a group or individual that monopolizes a disproportionate share of a resource.

6. Plan an energy awareness day program for the school. You might include short slide presentations, movies, speakers, contests, displays and posters.

7. Have a debate on this topic:

   Resolved: An individual's use of energy can be limited without undue loss of personal freedom.

8. Organize a panel to discuss these issues: Should mankind consume petroleum as a source of chemicals to produce synthetic materials? Who should make the control decisions on that issue? What are the alternatives? Should we also be concerned about the energy needed to produce natural materials (such as wool, cotton, and foodstuffs)? P.S. Where does chemical fertilizer come from?

9. Pretend you are representing the Secretary of the Interior and must help him decide on the best location for an oil pipeline from Houston to the rest of the state. Locate the line and defend the choice, aesthetically, environmentally, economically, politically.

10. Develop a personal profile of each member of an idealized five-member panel that must make ultimate decisions about the control of energy production.

Include data that reveals:

a. Political affinity
b. Educational background
c. Vocational background
d. Ethical standards, etc.

11. Each student bring in five unique pictures showing some energy misuse. Teams of five make into collage using all pictures. Write a poem (diamante - cinquain) depicting the collage.

12. Work in small groups to "manufacture" articles or art objects, and record all types and uses of energy involved in the process.

Suggested items for manufacture:

a. Candles - wax, molds, wicks, coloring agents, and candle holders.
b. Clay beads - formation of clay, firing, stringing, and pigment preparation and finishing.

Class can think of various alternative projects. If articles were to be used as items at a bazaar, more processes would be involved; this activity might be included in an economics unit where real profits and losses could be experienced. Can you develop a cost/pricing system based on the energy used to produce the product?

13. Divide the class into the following groups:

a. Manufacturers (including textiles, aluminum, automobiles);
b. Conservationists, Sierra Club;
c. City, county and state planners;
d. Oil companies, coal mine owners, foresters, teachers, workers.

Each group must assert its right to control the production and use of the energy resources of the world and must defend its position.

14. The class will speculate on the type of job he thinks was most prevalent when wood fuel was a major source of our nation's energy. Then consider this same problem regarding coal, oil, natural gas, electricity.

Suppose we were able to convert the sun's energy directly. What new types of jobs would be available? Which types of jobs do you think would be eliminated or reduced? Give reasons.

15. For discussion: A "traditional value" in this country has been that if something works, it has to be good. What would happen if that value were reworded so that it was

stated this way: "The value of a process or product must be to create the greatest social good". What implication would this have for policy-makers? How would it affect the growth of some industries? Where does energy fit into this picture?

16. Make a mural which describes the historical progression of fuel uses from wood to nuclear fuel based on man's progressive technological abilities. Include wood, peat, lignite, coal, oil, natural gas, nuclear fission and nuclear fusion.

17. Discuss the merits of land-use planning to ease population pressure and to utilize energy resources more efficiently.

18. It is not always possible to construct an electrical energy-producing power plant in the most desirable location. Suppose a geographic area needs more electric energy. Establish a set of criteria (rules or standards that you would apply to judge the desirability or undesirability) that might be used to locate a plant. Pick one of these:

    a. Coal
    b. Gas
    c. Wood
    d. Oil
    e. Hydro
    f. Nuclear
    g. Some other choice?

    Include these elements in the criteria:

    a. Location of plant
    b. Prevailing wind direction
    c. Water sources
    d. Fuel sources
    e. Economic impact
    f. Environmental impact
    g. Human resources

19. When a resource begins to become scarce, it's due in part to the difficulty of finding it, taking it out of the ground, processing it for use, and transporting it to market.

    Pick an energy resource, oil for example, and discuss what jobs might be created or eliminated as it becomes more scarce, e.g., more jobs for geologists but fewer gas-station attendants.

20. Have a debate on this topic:

    Resolved: Family structures change in response to limited energy resources. For example, what else is there to do if there isn't electricity for the television set?

21. List the countries who have the various energy resources (oil, natural gas, coal, etc.) and note their political ideology. What effects does this have on world politics and the availability of resources on the world market?

22. Many emerging nations have "nationalized" companies on their soil previously owned by the United States and other foreign countries. Does a country have to take over a company owned and operated by a foreign country which is inside their territorial limits? Explain.

23. Research the price changes in a barrel of crude oil for the past ten years. Graph your results. Make future projections.

24. Our society is based on the extensive use of the automobile. What are the differences in the types of fuel used in the automobile (regular, premium, lead-free)? Why are some more expensive than others?

25. Relate the cost per gallon of diesel fuel to gasoline. Explain the difference.

26. Through the use of charts, diagrams and models explain the conversion of fossil fuel to the mechanical energy which drives the rear wheels of a car.

27. Identify the major means of transportation in your community. Visit a bus station and examine the schedule and routes the buses take, their origin and destination. Interview a reservation clerk. Are more people using the bus now than one year ago? Calculate the cost per person per mile transported in a car, bus, train, ship and airplane.

28. Interview the transportation supervisor or building principal and obtain or compute the following information:

    a. the number of miles each school bus goes per day.

    b. the number of gallons each bus uses each day.

29. Compare the energy expended in foot pounds for the following means of transportation:
    a. walking,
    b. riding a bicycle,
    c. used in a car,
    d. used in an airplane over the same distance.

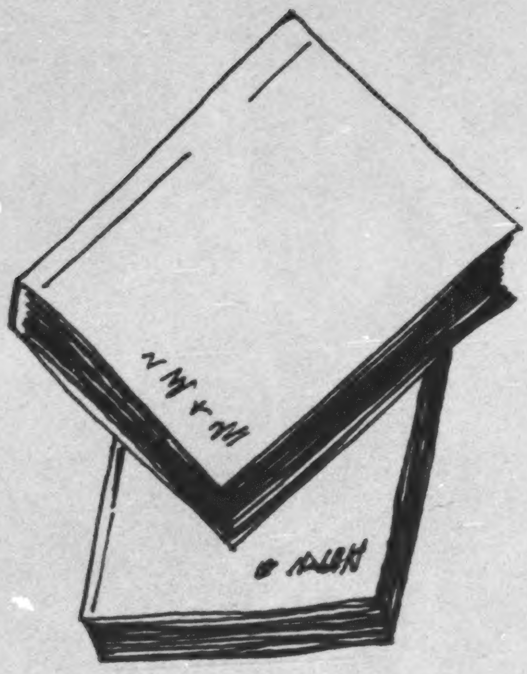
    Compare the time involved in each one of these and the costs.

30. Try to formulate more efficient bus runs; that is pick up more students with our bus. Remember, you have to

get them to school on time.

31. Make up an optional activity of your own.

32. Describe the voters' responsibility to require systematic and practical municipal planning to utilize sewage and garbage for the most appropriate limiting of pollution and recycling of minerals, materials and energy.



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A Teacher's Handbook on Energy
Feedback Report

The Governor's Energy Advisory Council actively seeks your ideas, comments and general suggestions about this Handbook. If you feel there are ways this Handbook could be improved, or if you develop additional activities, these should be submitted to Mr. Walter Tillman or Mr. Michael Scott.

Educational Programs
Governor's Energy Advisory Council
7703 North Lamar Boulevard
Austin, Texas 78752

We would appreciate information from you indicating how this Handbook was used in your particular school and which activities were especially helpful. Help us keep in touch with you.

When this Handbook is revised, your suggestions will be considered for inclusion.

* *

(Please print)

Name ____

Address ____

City ______________________ State _____________ Zip ___________

School ____

Where did you receive this Handbook? ______________________________

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1. All things considered, which of the following describes your overall feeling about A Teacher's Handbook on Energy.

   /_______________________/_______________________/
   Good   Neutral   Poor

   (a) If favorable, what did you particularly like about this Handbook?

   (b) If unfavorable, what do you particularly dislike about this Handbook?

2. Were you able to integrate any of this material into your regular courses?

   Yes   No

3. Please describe how you used the Handbook.

4. How could this Energy Handbook be improved?

5. Would you share with us learning objectives, activities, and background information which might be helpful to others using a revised Energy Handbook.